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Question-Asking Behavior of Faculty During Conceptual Instructional Design: A Step Toward Demystifying the Magic of Design

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Abstract

Questioning is a means of information gathering as part of information seeking behavior, including but not limited to: self-questioning, asking questions of others, ignoring questions, deferring asking questions, or denying there are questions. Questioning is critical to design synthesis, supporting learning, problem identification and solving, creativity, evaluation, decision making, and identification and reduction of uncertainty. Jon Kolko refers to design synthesis the *magic of design*, an abductive, creative sensemaking process generally invisible to observers and often to designers, making it difficult to formalize design and discounting the value of design research and synthesis. Extensive research exists on what designers do, substantially less on how designers think, and very little on cognitive questioning behavior during design from user-based perspectives.

The general goal of this study is to help illuminate information gaps that exist for faculty early in the instructional design process. The overarching goal of this study is to provide a starting point for future research on interventions to aid designers from all disciplines with question-asking during design, based on techniques used in commercial nuclear power. The general research objective is to empirically describe faculty's cognitive question-asking behavior during conceptual instructional design. Specific research objectives include exploring questions faculty ask, identifying uses faculty associate with the questions they ask, identifying patterns of behavior in the descriptions faculty provide, and exploring what faculty feel is important about question-asking during instructional design.

This qualitative, descriptive study applied Brenda Dervin's user-based sense-making methodology to explore actual questions asked by faculty using timeline interviews. Data was analyzed using deductive and semi-inductive content analysis, descriptive statistics, and design mapping of faculty's questions to other design domains.

Results include a variety of faculty questions, concerns, and behaviors including information seeking, concern for students and self, uncertainty about the current design situation, concerns about cross-disciplinary instructional design and complexity, expert/novice issues, and motivational techniques. Participants see value in asking questions during instructional design, but several communicated that they're not trained enough in instructional design. Multiple opportunities were identified for provision of design support and faculty development.

As a whole, this study offers two contributions to the fields of instructional design, information science, and design research. First, it provides in-depth exploration of questions asked by faculty designers-by-assignment and expert faculty instructional designers during early conceptual instructional design involving something that is new to them, highlighting problems experienced by faculty. It reaffirms some of the earlier conceptual work about the role of question-asking during design and the needs of instructional designers, and suggests means to aid faculty with instructional design and information seeking. Second, it provides a detailed example of application of design mapping to identify commonalities in question-asking behavior across multiple design domains, a partial proof of concept for design as a discipline. This study provides a basis for future research on interventions to aid designers with question-asking.

QUESTION-ASKING BEHAVIOR OF FACULTY

DURING CONCEPTUAL INSTRUCTIONAL DESIGN:

A STEP TOWARD DEMYSTIFYING THE MAGIC OF DESIGN

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Thanks,

-Sue

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CHAPTER 1. INTRODUCTION

"The Devil is in the details but so is salvation."

- Admiral Hyman G. Rickover. (M. Aurisicchio & Bracewell, 2013, p. 151).

1.1 Introduction

This chapter covers the rationale for the study, definitions of key terms, problem statement, the researcher's motivation for the study, research context, research objectives, an ad-hoc design mapping data analysis approach, and a brief overview of how the research objectives are addressed by the study.

1.2 Rationale

We have all seen examples of poor design: confusing online courses, automotive recalls, the Fukushima-1 nuclear accident, and products that break on first use. Suh (2001, 2013) defines design as an interplay between what the designer wants to do and how to achieve it in order to satisfy specific human and societal needs within a context for all design disciplines. Three hundred years after the industrial revolution began, design is still often performed by trial and error, evaluated based on experience, solution-focused rather than user-focused, and viewed as an art, trade, or talent rather than as a rigorous science. This approach leads to project failure, high cost, safety issues, frequent maintenance, and unhappy users. Our rapidly changing world makes it increasingly difficult or impossible for designers to rely on experience. The idea of the designer as a creative genius working from inspiration still lives on, but this viewpoint no longer supports the cognitive demands and information load of complex design. Global competition requires finding better ways to perform and teach design (Ralf, 2007; Schneider, 2007; Suh, 2013).

The focus of design research is to develop a scientific approach to design and expand research on design cognition, including how people learn to design, how to improve design education, and development of techniques to aid designers. The design field has been slow to generalize, codify, and systemize design for design support and education (Cross, 2007; Hsu & Woon, 1998; Ralf, 2007; Suh, 2013; Xiao, Park, & Freiheit, 2011). Design is increasingly viewed as an information-intensive, high-level, complex cognitive ability rather than a form of problem-solving, with features of expertise that require additional research (Cross, 2007; Kolko, 2010b). Kolko refers to design synthesis as the *magic of design*, an abductive, creative sensemaking process that is generally invisible to observers and often to designers. This invisibility makes it difficult to formalize design, and discounts the value of design research and synthesis (Kolko, 2010a). Design cognition research is necessary to demystify the magic of design and improve support for information seeking, gathering, and evaluation during design.

Design research and practice support the concept of design as a discipline, the idea that there are design commonalities across all areas of design (Oliva & Hubbard, 2015; Rothwell, 2013). Yet, not all who are engaged in design have been trained in design. In fact, as much as 95% of instructional design is performed by designers-by-assignment: those assigned do instructional design without formal training (Merrill & Wilson, 2007). This implies that faculty across all disciplines who create new instructional materials and courses most often are designers-by-assignment.

Expertise has been shown to be domain-specific and practice-based (Ericsson & Lehmann, 1996). Even highly trained expert designers can struggle with design when they are engaged in design involving a topic or method that is new to them or cross-disciplinary (Cross, 2004; Ericsson & Lehmann, 1996; Oliva & Hubbard, 2015). As verified at the ICAD 2013 conference, newness is a situation commonly encountered during conceptual design, one of the areas that designers tend to struggle with, especially if complexity and information overload are involved (Rothwell, 2013).

Conceptual design is the beginning stage of design, involving preliminary identification and evaluation of user needs, design problems, ideas, options, solutions, and associated risk, resources, and requirements. Decisions made during conceptual design generally significantly influence performance, reliability, safety, development time, usability, and quality of the final design at a time when knowledge of design requirements and constraints is often approximate or unknown. Conceptual design is becoming increasingly information intensive and complex, often committing the majority of project cost and increasing risk. Conceptual design is the most difficult, important and least understood part of design, in need of substantial additional research (Hsu & Woon, 1998; Huang, 1992; Oliva, 2013; Rothwell, 2013; Suh, 2013). Dorner refers to this process of working with little knowledge of requirements or constraints as *intransparence*, having no direct access or no access at all to needed information, requiring decisions to be made based on uncertain information (1996). Conceptual design may result in anything from a general idea for a work of art to a fairly detailed initial design for a new steam generator in a nuclear power plant, depending on the context and expectations for initial design planning.

The goal of this study is to investigate question-asking behavior during conceptual instructional design among faculty who have performed instructional design involving a topic or method that is new to them or cross-disciplinary. Information gaps, patterns of designing and information seeking behaviors, and user needs are explored as a step toward improved design and education support. Examples of patterns of behavior include: actions, sequences of actions, questions, problems, uses, etc. across people, topics, or situations, and commonalities between questions asked by faculty and questions asked by designers in other disciplines.

Definitions of key terms are provided in Section 1.3 (additional definitions in Appendix A), followed in Section 1.4 by discussion of the research problem.

1.3 Definition of Key Terms

Definitions of key terms used in this study are presented below. Additional definitions are provided in Appendix A, Glossary.

Axiomatic Design: An approach to design developed by Nam P. Suh at MIT and intended to be applicable for all design disciplines. The two axioms of axiomatic design are to maximize the independence of the functional elements and minimize the information, or complexity, in order to guide the design process to the best possible solution for the desired functions (Suh, 1990, 2001, 2005, 2013).

Behavior: The actions or reactions of a person or animal. The manner in which something functions or operates (Houghton Mifflin Company, 2009).

Conceptual Design: The beginning stage of design, involving preliminary identification and evaluation of user needs, design problems, ideas, options, and solutions, and associated risk, resources, and requirements.

Conceptual Instructional Design: The earliest stage of instructional design, involving preliminary design activities (see Conceptual Design and Instructional Design). Conceptual Instructional Design begins when an individual first realizes that there may be a need to undertake some form of instructional design activities. This initial stage often focuses on early needs analysis, but may begin with, for example, review of technical information; research to interpret associated regulations, procedures, or policies; or a sketch of the item, idea, or process of interest (Oliva, 2015).

Design: The creation of engineered systems that satisfy specific human and societal needs within a context (Suh, 2013).

Design as a Discipline: the idea that there are design commonalities across all areas of design.

Design Mapping: A strategy for revealing a complex of relationships between design representation and thinking, technology, culture, and aesthetic practices, often focused on visualization of data and ideas (Newman, 2013).

Helps: See *Uses*.

***Hurts:* See *Uses*.**

Information Seeking: A conscious effort by an individual to acquire information in response to a need or gap in knowledge (Case, 2002; T. D. Wilson & Vickery, 1994).

Instructional Design: *"The field of instructional design and technology (also known as instructional technology) encompasses the analysis of learning and performance problems, and the design, development, implementation, evaluation, and management of instructional and non-instructional processes and resources intended to improve learning and performance in a variety of settings, particularly educational institutions and the workplace. Professionals in the field of instructional design and technology often use systematic instructional design procedures and employ instructional media to accomplish their goals. Moreover, in recent years, they have paid increasing attention to non-instructional solutions to some performance problems. Research and theory related to each of the aforementioned areas is also an important part of the field"* (R. A. Reiser, 2012).

Questioning: Inquiring. The range of human behaviors having to do with questions, including but not limited to: 1. self-questioning (verbally or mentally asking questions of or mentioning concerns to yourself), 2. asking questions of others (externalized questioning), and 3. having a questioning attitude. Questioning is part of information seeking behavior. Questioning can occur during any phase of representing, information seeking, interacting, or designing.

Sense-Making Approach: The cognitive and physical behavior of an individual as applied to cognitive movement through time-space (B. Dervin, Foreman-Wernet, & Lauterbach, 2003b).

Uncertainty: A state in which the order or nature of something is unknown, unpredictable, unreliable, risky, doubtful, undecided, questioned, or not definitively ascertainable.

User-based: A design/development or research approach that captures and describes behaviors from the user perspective (Nilan & Mundkur, 2007).

User Behavior: Human actions, reactions and cognition with respect to use of information, technology, products, processes, or services of interest.

Uses: The ways that people put answers to their questions to work. Positive uses are called "helps." Negative uses are called "hurts." (B. Dervin & Nilan, 1986).

1.4 Problem Statement

Questioning is a means of information gathering as part of information seeking behavior, including but not limited to: self-questioning (verbally or mentally asking questions of or mentioning concerns to yourself), asking questions of others (externalized questioning), ignoring questions, deferring asking questions, or denying that there are any questions (Graesser & Olde, 2003; Gross, 2006). Questioning is critical to design, supporting learning, problem identification and representation, problem solving, development of a range of design options, evaluation, decision making, and identification and reduction of uncertainty (Oliva & Hubbard, 2015). Questioning can lead to new thoughts and creativity (Schank & Childers, 1988). Literature review has shown there is extensive research on what designers do, substantially less research on how designers think, and very little research on cognitive questioning behavior during conceptual design, particularly from a user-based perspective.

Asking good questions is hard work. Systematic, iterative questioning during design requires a high level of individual dedication to avoid complacency (Hubbard, 2009). Designers don't always know what to ask, could become fixated or overwhelmed, may become complacent, and struggle with the complexity and uncertainty of ill-defined design problems (Cross, 2004; Davidson & Sternberg, 2003; Mendonca, 2009; Oliva & Hubbard, 2015; Ormerod, 2005). Experienced designers are likely to find design to be easier than novices would, but new domains and complex problems can challenge even the most experienced designers (Cross, 2004). Designers' understanding of question-asking behavior is important. Negative perceptions of question-asking can lead to not asking questions, asking fewer questions or inappropriate questions, or other behaviors that can contribute to failure to identify design risks (Oliva & Hubbard, 2015).

Questioning is crucial for cross-disciplinary work and work in unfamiliar domains (Oliva & Hubbard, 2015). Expertise does not necessarily transfer well to new domains (Holyoak, 1991). On an affective level, questioning can be an enjoyable mental or social exercise, or, as Roger Schank points out, questioning may be perceived as an irritant or as a source of fear (Schank & Childers, 1988). A lack of systematic, broad questioning can contribute to poor design (instructional or engineering design), resulting in anything from a few users not understanding a lesson or disliking a product to large-scale disaster. The Chernobyl nuclear power plant accident is an example of what can happen when people become complacent and do not ask questions (Chernousenko, 1991; G. Medvedev, 1991; Z. Medvedev, 1990; Mould, 2000; Munipov, 1991; U.S. Nuclear Regulatory Commission, 1987). Accident analysis for Three Mile Island, Chernobyl, and Fukushima plants support the importance of questioning as part of a strong nuclear power safety culture (Institute of Nuclear Power Operations, 2004; Nuclear Reform Special Task Force, 2012; U.S. Nuclear Regulatory Commission, 1979a, 1979b, 1987; Yasui, 2012).

Literature review for this study supports the concern that cognitive aspects of question-asking during design, such as the basis for and sources of questions, question-asking strategies, designer's understanding of the uses and values of questions, and how designers act on and resolve their questions are not well understood, particularly for conceptual design. This is a gap in current research that is worthy of investigation. A better understanding of the needs of people performing conceptual design could help us provide improved design support. Design support is an area I have been interested in throughout my career.

1.5 Motivation for the Study

I became interested in question-asking during design while working in the commercial nuclear power industry as a training configuration management coordinator, a position involving instructional and engineering design. I participated in engineering design teams on a daily basis for over nine years, at one point assigned to 150 design teams simultaneously, across multiple disciplines and a wide variety of design projects. I have lived the concept of design as a discipline at a higher level than most design researchers, as verified by conversations at the ICAD 2013 conference.

Based on my industry and academic experience, literature review, and discussions and observations at the ICAD 2013 conference, there is a need to better understand and support cognitive questioning behavior during design, and a current lack of effective means to teach designers and design students to ask better questions. While there are multitudes of issues other than questioning behavior that can affect design (a few examples are budget, managerial decisions, materials, climate, schedule, and process), question-asking during design is an area I am passionate about and highly qualified to investigate.

My interest in instructional design and learning more about the problems that faculty face during instructional design stems from my work in nuclear power. This is the basis for the study context discussed in the next section.

1.5.1 Research Context

Conceptual instructional design is defined in this study as the earliest stage of instructional design, involving preliminary design activities. Some instructional design models describe early instructional design more narrowly, for example by specifying that user requirements analysis is separate from and prior to concept design (Smaldino, Lowther, & Russell, 2007; Smith & Ragan, 2004). A broad definition of conceptual design is preferred by design researchers as a more realistic reflection of the iteration and complexity of information-intensive conceptual design (Rothwell, 2013). Conceptual instructional design in higher education has been selected as the proposed research context because any subject matter and audience may be involved, providing opportunity to obtain broad perspectives on question-asking, and due to the high percentage of Merrill and Wilson's (2007) designers-by-assignment in the field of instructional design.

Much of the research focus for instructional design and information seeking in education has been on external communication, student perceptions, instructional methods, questioning of subject matter experts, questioning of students in the classroom, etc., rather than on instructional designer's needs (Ciardiello, 2012; Jonassen, 2004; Keppell, 2001). We do not have a good understanding of the cognitive behavior of instructional designers, especially during conceptual instructional design (Perez & Emery, 1995; Rowland, 1992, 1993). We know that as much as 95% of instructional design is performed by designers-by-assignment and that many instructional products fall very short of their potential (Merrill & Wilson, 2007).

We need to understand the problems experienced by designers and designers-by-assignment to improve instructional products and strategies, including online courses. Investigating question-asking behavior of faculty, including designers-by-assignment, during conceptual instructional design can provide insight into their information seeking strategies and needs, and provide a basis for improved conceptual design support.

Although the area of instructional design in higher education has been selected as the context for the proposed research, information designers for websites, artistic designers, engineers, architects and other designers need similar support for information seeking, gathering, and evaluation during design, and thus can benefit from the results of this research (McCandless, 2010; Rothwell, 2013; Tufte, 2006).

With the research gap identified and the research context established, the research objectives were developed.

1.6 Research Objectives

This section discusses the research objectives for the study. Assistance with questioning is an identified need by both novices and experts, particularly in the early stages of instructional design when uncertainty is greatest (Rothwell, 2013). We do not know what questions faculty ask during conceptual instructional design, what resources faculty may already be using to aid with questioning, or how questions asked by faculty may transfer to other design domains.

The general research objective is to empirically describe participants (higher education faculty) articulations of their own cognitive question-asking behavior during conceptual instructional design. The overarching goal of this study is to provide a basis for future research on interventions to aid designers from all disciplines with question-asking during design. Participants were interviewed about a recent conceptual instructional design experience to obtain data for investigation of the research objectives.

Specific research objectives include:

RO1: To explore questions faculty ask during early conceptual instructional design.

RO2: To identify uses that faculty associate with the questions they ask during their conceptual instructional design experience (Example: Did it help or hurt?).

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

RO3 ties to the overarching goal of this study: to provide a basis for future research to investigate whether techniques used to help people with question-asking during design in commercial nuclear power can be useful to help designers with question-asking during design in domains outside of nuclear power. During development of this study, a common response from academic peers and others to the researchers' enthusiasm about research on techniques from nuclear power was 'I don't care what you learned in nuclear power because nuclear power is nothing like what I do.' As a potential barrier to future research, this is an issue that needs to be addressed. People don't see the connection between nuclear power questioning and the questioning that designers in other disciplines do. An ad-hoc design mapping analysis was developed to explore elicitation of data that could be helpful to illustrate a connection between nuclear power questioning and the questioning that designers in other disciplines do.

1.6.1 Design Mapping: An Ad-hoc Data Analysis Approach

Design mapping is a data analysis strategy for revealing complex design relationships (Newman, 2013). An ad-hoc design mapping analysis approach was developed to explore extending analysis of questions asked by faculty beyond identification of patterns of behavior within the study data to identification of similar questions asked in other design disciplines. This was done by having design experts from fields other than instructional design review the study data and try to identify similar questions asked in their design domain(s). The ad-hoc design mapping analysis was used to explore transferability to other design domains and provide a partial proof of concept for design as a discipline. Refer to section 3.7 and Appendix O for details.

No prior examples of this application of design mapping were located, and the researcher did not know what to expect. Will designers in nuclear power and other disciplines wish to participate in a design mapping team? Can designers in other design disciplines identify commonalities between the questions asked by faculty and questions they ask while designing in their own domains? What does implementation of design mapping involve? Will team members map 10% of the data, or 15%, or maybe as much as 25% or 30% of the data? What form will results take?

Commonalities identified for questions asked during design across multiple design domains provide a partial proof of concept for the idea of design as a discipline (the idea that there are design commonalities across all areas of design), suggest transferability of question-asking results across a range of design domains, help refute the argument about 'nuclear power is nothing like what I do' by illustrating similarities in question-asking during design, and support recommendations for future research.

RO4: To explore what faculty feel is important about question-asking during instructional design (Examples: How does it make a difference in the quality of instruction as compared to when they overlook or leave out questioning? What are the most important things faculty want to share about question-asking, such as critical issues, something they are confused about, or a question they wish they had asked?).

Satisfying these research objectives will advance knowledge of design cognition with respect to question-asking during design, provide information on the needs of instructional designers during design, lead to recommendations for designers-by-assignment or novice instructional designers, and provide insight on the concept of design as a discipline, as well as a basis for future research.

1.7 Overview: Addressing the Research Objectives

Data was gathered on participants' questions, steps (actions or events), helps, hurts, and the basis and sources of questions. The study research methodology in Chapter 3 guides participants through discussion of questions asked during an instructional design experience, focusing on cognitive aspects of asking and resolving those questions. This provides insights on participant's instructional design experiences.

Analysis of actions taken, the sequence of actions, problems experienced, context for questions and needs, helps (positive uses of questions), "hurts" (negative uses of questions) question sources, and patterns of behavior can provide recommendations for improved user support (B. Dervin, 1983; B. Dervin & Dewdney, 1986). Data may help us improve our understanding of the problems experienced by faculty, provide insight into the context for their questions/concerns, and provide directions for future research. Recommendations for addressing the problems experienced by faculty could potentially be a step toward improving instruction in higher education

Chapter 2 covers literature review for the study.

CHAPTER 2. LITERATURE REVIEW

"Questions are the heart of everything we do. The whole design process is nothing more than a set of questions."

- Bill Wolfson, Electrical Engineer and Design Educator, ICAD 2013, with permission.

2.1 Introduction

This chapter introduces the conceptual framework for the study, including: design, design as a discipline, and the integrated nature of the associated fields of User Behavior, Instructional Design, Cognitive Science, Information Technology, and Design Science. Pertinent literature, research, and perspectives are discussed. Brenda Dervin's Sense-Making Approach is covered in detail.

2.1.1 What is Design?

In this study design has been defined as an interplay between what the designer wants to do and how to achieve it in order to satisfy specific human and societal needs within a context for all design disciplines (Suh, 2001, 2013). However, this definition doesn't describe the nature of design. Design has been described in many ways: as problem solving, inventing new things, the tension between what is and what ought to be, fit/form/function, individual heroic creation, making something new that fits with reality, manipulating representations of an imagined future reality, the science of imagination, appearance, optimization, enumerating and evaluating aspects of solution space, addressing wicked problems, debugging something into reality, and more (Harrison, 2008).

Traditional perspectives on design have evolved over many years, as shown in Figure **1**. Design was first viewed as separate from the creative disciplines of art, science, and engineering. The timeframe and extent of adoption of these perspectives varies among disciplines and is still a topic of debate. There was a gradual shift to a view of design as either two or three disciplines, largely dependent on individual beliefs about the nature of engineering. Today, engineering is most often seen as a design discipline, although this is still a point of contention.

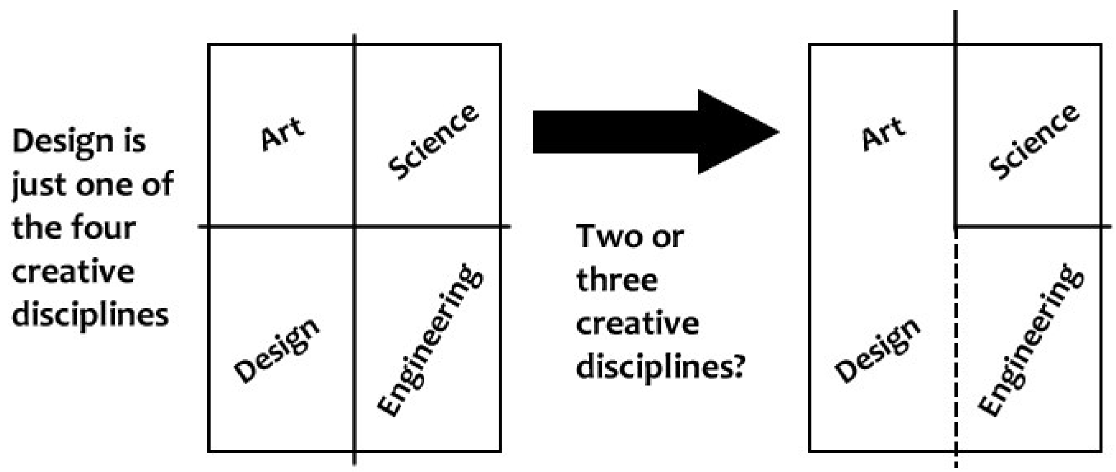


Figure 1. Evolving Perspectives on Design

Adapted from The Plenitude: Creativity, Innovation, and Making Stuff (p. 7), by Rich Gold, 2007, MIT Press.

For example, some architects view engineering as merely building things, with no designing involved because they feel engineering is not creative and does not result in art (Rothwell, 2013). This perspective ignores the fact that engineers design the materials and objects that architects use to construct beautiful buildings, and that to the engineer, power plant systems can be as beautiful as an architectural masterpiece. Design involves creating something new to solve a human problem. Building is the process of constructing something that was previously designed. What is art to an engineer may not necessarily be seen as art by an architect, artist, or musician, yet all involve design (Oliva & Hubbard, 2015).

A possible contributor to the perspective on what is and isn't design as an art may be that in general, people in modern society are not raised to view engineering as art, and engineering is not a very visible profession. Things have not always been that way. As an example, when the Roman aqueducts were built between 312 BC and 226 AD, they were considered to be glorious testaments to Roman engineering. Although we know little about the military hydraulic engineers such as Nonius Datus who designed the aqueducts, engineering in that era was quite visible as a profession, popularly supported by the highest levels of society, and seen as both art and science (Chanson, 2002; Schram, 2013; United Nations of Roman Victrix, 2013).

Design of any type is a creative, dynamic, and generally iterative process. In the more often highly proceduralized design arenas such as engineering and instructional design, it can be easy to focus on logical processes and end results, and sometimes people forget about the importance of creativity to design. Engineering in particular is often seen as a rigid process, in spite of the fact that the most sophisticated, systematic, and successful engineering design processes, such as those in commercial nuclear power, are quite creative, flexible and adaptable. Within instructional design, the multitude of logical and methodical design models and processes may contribute to a tendency to neglect open-ended, creative questioning such as 'What if…?" or "How would that work?" (Hubbard, 2015b).

The concept of design as a discipline arose in the 1940s in very specific military and scientific contexts, and is discussed in more detail in the following section.

2.1.2 Design as a Discipline

Design as a discipline is the idea that there are design commonalities across all areas of design. Initially credited to Admiral Rickover and the U.S. nuclear submarine program in the 1940s (Duncan, 1990), over the past twenty years or so the concept of design as a discipline has begun to take hold more generally, along with the idea that there is a science of design (Brown, 2011). The concept of design as a discipline as discussed in this study is illustrated in Figure 2.

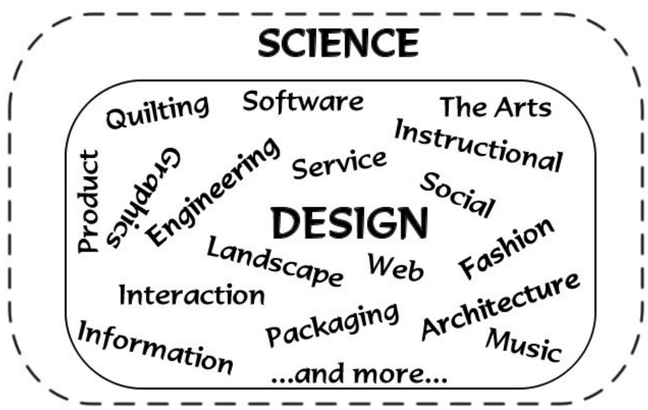


Figure 2. Design as a Discipline: Working Toward a Science of Design

Design as a discipline is reflected through commonalities between all of the design areas, each of which involves creativity and, to an extent, artistry. Over the long term, it is hoped that research will result in a comprehensive science of design. The concept of design as a discipline is an important part of the conceptual background for this study, as my nuclear power industry experience living design as a discipline is the basis for my interest in future research testing interventions to aid designers in non-nuclear design fields with question-asking. The evolution of the concept of design as a discipline is discussed in more detail in the following section.

2.1.3 An Integrated History of Design as a Discipline

The concept of design as a discipline and the birth of design science are often viewed as being primarily based in engineering design, but developments in the fields of Instructional Design, User Behavior, Cognitive Science, and Information Technology have all contributed. From a very broad perspective, these fields extend far into the past. For example, instructional design reaches back to when our early ancestors had to think about how to teach the use of fire and stone clubs. Information technology is sometimes viewed as beginning with the use of a reed stylus to write on clay tablets in 3500 B. C. (Oriental Institute of the University of Chicago, 2008). Information user behavior can be associated with cave paintings in 20,000 B.C. (Nunberg & Brownstein, 2002). However, the most common perspective on these areas is that they began to develop toward the fields as we know them today in the early-mid 20th century. This section provides a chronological outline of these fields.

The 1940s: The interdisciplinary nature of these fields becomes apparent during the 1940s. Information technology developed rapidly, spurred by World War II, and artificial intelligence research emerged in conjunction with development of first generation computers. Much of the foundation of the field of instructional design was based on efforts to develop instruction for rapid training of large numbers of military personnel to perform complex tasks, often with use of new audiovisual devices. Wartime training models were used in business and education, and user studies expanded to include military training and organizational concepts of efficiency and performance (R. Reiser, 2007c). This was the first effort to perform organizational training on a huge scale, and although somewhat primitive compared to instruction today, at the time this was quite an accomplishment. Frustration with problems encountered during this era led to many advances in instructional design over the next several decades. The discipline of technology, a phrase Admiral Rickover used to describe his approach to technological innovation and operation, and the precursor to the discipline of design, was developed by U.S. Navy Admiral Hyman G. Rickover to ensure improved nuclear training and safe design and operation of nuclear submarines (Duncan, 1990).

The 1950s: During the 1950s, the Space Race drove development in all of the fields. A systems approach to instructional design and user studies became prevalent. During this era, and unfortunately often still today, user studies were observer-oriented with the researcher believed to have a privileged perspective on users' needs, rather than obtaining user needs from users themselves. Although not user-based research, this era was still a step forward, considering users' needs across broader contexts such as scientific users and television-related behaviors (R. Reiser, 2007c).

An interesting but little-known development in the 1950s was Admiral Hymen G. Rickover's development of a performance-oriented systematic approach to training for his U. S. Navy nuclear submarine program. This approach is applied in U.S. nuclear power plants today, and is a classic example of institutional constancy (Crawford, 1998). Although Rickover worked with Robert Gagne and other academic experts, his work reflects one of the historic difficulties of instructional design. Many academic researchers transition into military projects, but few military personnel transition to academia, resulting in some filtration of academic research results to the military, but little dissemination of military research results among academics (Ellis, 1986). Increasing security issues have compounded this problem in both directions today (Hubbard, 2015a).

The 1960s: The 1960s reflect ongoing overlap and expansion of the fields. Robert Glaser's concept of instructional design as learner analysis, design, and development of instruction was a starting point for formal definition of the field of instructional design (1962). The area of Design Studies emerged as a new discipline during the 1960s. Although design discussions have been documented since the time of Aristotle, the emergence of Design Studies as an academic discipline as we know it today occurred in 1962 at The Conference on Design Methods in London, England. The conference was called to address concerns about the need for more scientific design methods, in parallel with overall emphasis on science because of the Space Race. The need for education on a science of design in universities became a concern, supported strongly by Herbert Simon (Cross, 2001). Many of the same educational and instructional issues that were brought up during the 1950s and 1960s, such as the need for innovation in instruction, appropriate presentation of information via automated (computerized) systems, appropriate feedback, effective instructional techniques, and the advantages and disadvantages of classroom instruction versus automated instruction are still issues of concern today (Ofiesh & Meierhenry, 2004).

The 1970s: The 1970s reflect growth and increasing maturity of the fields. The fields of cognitive science and human-computer interaction were formally established (Driscoll, 2007). The need for instructional design, education, and user research increased as new computer technology was adopted by military, industry, and education. Information user behavior studies expanded beyond the library and military arena to include business and scientific settings (Case, 2002). A key development in user research was Brenda Dervin's Sense-Making Approach, the beginning of a user-based approach to information seeking and use, and an important shift away from focus on systems and information sources (Tidline, 2006).

Design studies experienced a backlash against scientific design methods during this period. Some researchers began a trend toward viewing design as "wicked" problem solving, not amenable to scientific techniques (Cross, 2001). This perspective was based on research in cognitive psychology supporting a problem solving framework for studying and describing design (Eastman, 2001). A milestone in design research occurred when Nam Suh published the first journal article on axiomatic design in 1978, a new design approach intended for use in all design disciplines (Suh, Bell, & Gossard, 1978). Refer to section 2.6.3.1 for more information on axiomatic design.

The 1980s: During the 1980s, computer technology became widely available in industry, and spread into homes and educational institutions as technology prices dropped. With this came increased awareness of the massive amounts of information that could be made available to users, and interest in application of information technology to enhance performance, particularly in complex and critical work environments. The field of instructional design shifted focus from a systems approach to a constructivist focus, a more user-centered and cognitively oriented perspective. Cognitive science research was increasingly targeted toward development of applications and models to benefit users, such as expert systems and intelligent tutoring systems (Association for Computing Machinery, 2007; Broderick, 2001; Carbonell; Case, 2002; Mantex, 2009; R. Reiser, 2007c; White, 2005b; M. Wilson, 2004).

User behavior research tended toward a more user-oriented approach with new models of information behavior (Taylor, 1984; T.D. Wilson, 1981; T. D. Wilson, 1984). However, research remained largely focused on systems and application development and was performed largely without input from users. An exception to this was Nilan and Fletcher's user study of information behaviors in preparation of research proposals. The proposal submission process was treated as a model for an information system, using a modified version of Dervin's Sense-Making Approach to elicit and analyze data from users who had recently submitted proposals. Results provided a user-oriented set of criteria for information organization that could be applied to system design, a first in the field (Nilan & Fletcher, 1987).

Design Studies and Design Research began an evolution from discipline to an emerging cognitive science subfield of Design Science, establishing multiple scholarly journals on design research, theory, and methodology, such as *Design Studies* and *Design Issues* (Design Research Society, 2013; MIT Press Journals, 2015). Systematic approaches to engineering design were developed, leading to a proliferation of engineering design methods textbooks and increased emphasis on design education (Cross, 2001, 2006).

The 1990s: The 1990s saw an explosion in use of information technology due to the Internet and the advent of large-scale online learning and e-commerce. Use of multimedia and wireless technologies is reflected in research, development, and practice of instructional design, and in user behavior studies. Information behavior modeling trended toward more general models, although there is still no comprehensive single theory of information behavior (Case, 2002; Fisher, Erdelez, & McKechnie, 2006). The spread of information technology resulted in increasingly complex tasks for users, a corresponding interest in expertise research within the field of cognitive science, and a focus on complex learning and skills (Clark & Mayer, 2007; Driscoll, 2007). Some of the top experts in instructional design were involved in development of large automated instructional design aid tools, primarily targeted at the military (Kasowitz, 1999). The field of design studies continued to grow, publishing additional journals such as *Research in Engineering Design* (Tel Aviv University, 2015)

The 2000s: Since 2000, user focus and complexity have increased across the fields, with, emphasis on humans as integrated into information environments (Bates, 2006). Constructivism, holistic models of instruction, rich learning, and complex learning are key issues in instructional design (R. Reiser, 2007c), along with dealing with technology (Totten & Schuldt, 2009). There has been significant growth in online learning across industry, business, all levels of education, and the military and government, along with increased reliance on informal learning. Use of social media and informal methods is likely to result in a learning curve for many instructional designers to learn how to support these new approaches, redefine roles, and better capture and enhance informal and social learning (R. Reiser, 2012; Rossett & Hoffman, 2012).

An increasing focus on social constructivist approaches to information behavior, collaboration, coordination, and humans as integrated into information environments can be seen in information user behavior research (Fisher, et al., 2006), but there still appears to be a lack of application of findings to technological development (Case, 2002). Flipped classrooms are everywhere, basically a new iteration of constructivism (Jonassen & Land, 2012).

The field of Design Science has continued to grow, with axiomatic design now being taught at some of the top engineering and other design schools. The concept of design as a discipline, now over 70 years old in the world of nuclear power, is beginning to gain recognition and acceptance in other design realms (Rothwell, 2013). This study will add to our understanding of the concept of design as a discipline by addressing an aspect of design that has received little attention; the existence of commonalities in question-asking behavior during design across multiple design disciplines. This is an important proof of concept for future research.

The following section discusses user behavior in more detail.

2.2 User Behavior

Areas of dispute within the field of user behavior include the appropriate perspective to take with respect to users, applications of theory and models, what constitutes theory, and ongoing confusion over definitions of common terms (Case, 2002; Davenport, 2010;

B. Dervin & Nilan, 1986; Fisher, et al., 2006; Hoffman, 2009; Pollock, 2002; T.D. Wilson, 1981). There are almost as many perspectives on user information needs and uses as there are authors. The focus of this section is on the distinctions between the two primary approaches to user studies, traditional and user-based approaches, and how each is or is not applicable for this study.

2.2.1 Traditional User Studies

Most user research studies investigate how people use systems or information, instead of investigating users themselves, or other aspects of information seeking behavior (T. D. Wilson & Vickery, 1994). A traditional purpose of user studies has been to predict information use on the basis of individual traits, an approach which has not been successful (B. Dervin, et al., 2003b). The distinction between a focus on the how and what of information seeking and use, the traditional approach to user studies, and a focus on users themselves (a user-based perspective) is important. A user-based approach is more likely to provide accurate and relevant data on user needs (B. Dervin & Nilan, 1986).

Traditional user research relies on observation techniques that are often intrusive, focused on a user's physical and verbal actions, limited by narrow context of specified user tasks, or focused on user demographics rather than user's actual information needs and uses. The traditional approach is based on understanding of the users' information needs and uses as perceived by the observer. This tends to result in user support that does not meet user needs (B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986; Nilan & Mundkur, 2007).

A shift toward increased focus on user behavior began in the 1980s and is discussed in the following section.

2.2.2 Shifting Toward a User Focus

Communication of information was seen initially as a linear "information provider" process, and in the 1980s began to be viewed as an information exchange model based on Tom Wilson's information behavior modeling (Bawden, 2006). Many researchers viewed information as a thing, and users as message recipients, ready to be filled with pre-determined "bricks" of information, without considering actual user behavior. Experts generally determined user's needs during system and information design, resulting in an expert-user understanding gap that frequently frustrated users (B. Dervin, 2005; B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986). Researchers were struggling to discover the basics of information behavior, viewing information use in terms of the formal information system of paper and various other non-human resources (Bates, 2002).

A gradual shift in perspective occurred for some user behavior research, with user-focused studies investigating issues such as classification of user characteristics and information needs and uses, and relationships between roles of users and information seeking behavior (Case, 2002; T. D. Wilson & Vickery, 1994). A conceptual shift toward an "information in context" approach to research on individual information seeking and use in practical contexts began (Bawden, 2006).

An example was Chen and Hernon's 1982 study of information seeking by New England residents, which showed the individual and context-driven nature of information seeking by citizens and the importance of interpersonal contacts as providers of information (Bawden, 2006; Case, 2002). This was the start of a transition from quantitative methods and an objectivist philosophy (information with constant meaning and an absolute reality) to more qualitative methods and a subjective philosophy (reality and information do not have constant meaning). Researchers started working toward a better understanding of user behavior instead of descriptions of information and system use (Bates, 2002; B. Dervin & Nilan, 1986; T. D. Wilson & Vickery, 1994).

This subjective approach increased focus on users, but was still largely observation-based rather than user-based. The need for conceptual growth and improved models of information behavior was emphasized, with increased focus on user-defined information needs and uses, and the need for research to inform practice. The debate on these issues was touched off by Dervin and Nilan's annual review article on user research, still one of the most highly cited articles in the field (Bates, 2002; B. Dervin & Nilan, 1986). This article offered alternatives to the traditional approaches to user research, stressing situatedness and cognition, with humans actively constructing information rather than being passive processors of information, and focusing on application to practice (B. Dervin & Nilan, 1986). This initiated a larger shift toward focus on the viewpoint of the user: a user-based perspective.

2.2.3 The User-Based Perspective

Establishing a user-based perspective requires questioning how people determine information needs, and how they interact with systems in connection with these needs prior to system or tool design rather than basing design on expert's opinions of user's needs (B. Dervin & Nilan, 1986). A user-based perspective helps ensure that the real needs of the users are incorporated by asking users for their own perspective. Tools or systems can then be designed based upon their actual needs. Dervin's approach applies a disciplined interview communications technique with prescribed talking and listening turn-takings, which focuses both researcher and user communication patterns on the user perspective (B. Dervin & Devakos, 2010).

Taking a user-based perspective and investigating actual user needs, issues, and problems (based on empirical patterns in how they think, feel, and talk about them) makes it more likely that designs will be effective from the user's viewpoint. This minimizes the necessity for trial-and-error design and post-design revision, and reduces overall costs. A user-based approach often provides more accurate, valid, and reliable data on user perspectives than methods based on user observation or user characteristics. A user-based approach improves design and development of systems and tools, provision of user support services, and effective education and professional development (B. Dervin & Nilan, 1986; Nilan & Mundkur, 2007).

This study will investigate actual user needs and patterns of behavior based on what faculty think, feel, and talk about conceptual instructional design experiences, and is expected to provide accurate, valid and reliable data.

User-based research relies on user data obtained through conversations with actual users about their real-life information seeking experiences, in the user's own context, where the user is the most qualified expert on his or her information needs and uses.

Asking the user about a specific type of situation, such as an online purchase, bounds the user experience and permits investigation of relevant, universal aspects of an information seeking situation.

While the details of an information seeking experience may vary, patterns can be recognized across similar situations. For example, users may purchase different products for different reasons, but each will still progress through a similar series of steps to make their purchase, such as investigating product options, choosing a specific product, and making the actual purchase.

This study applies Dervin's timeline interview technique, which was developed specifically to obtain user data through conversations with actual users (B. Dervin, 1983; B. Dervin & Dewdney, 1986; B. Dervin & Nilan, 1986).

This study focuses on a user-based perspective on design.

2.2.3.1 A User-Based Perspective on Design

The user-based approach provides an improved understanding of humans, not just an understanding of physical objects and systems. We cannot really understand humans unless we interact with each other. However, it is also important to remember that we do not always entirely understand the physical aspects of design, or the power of Mother Nature (Oliva & Hubbard, 2015).

The power plant operators at Chernobyl did not understand their plant design, with catastrophic results (U.S. Nuclear Regulatory Commission, 2007). Root causes of the Chernobyl accident include (G. Medvedev, 1991):

- Plant personnel had little awareness or understanding of the risks inherent in their plant design, potential accident conditions, or appropriate emergency procedures. Personnel had an uneducated blind faith in the safety and superiority of their plant that prevented them from reacting appropriately.
- Plant design and safety systems were extremely poor, resulting in a very high level of risk.
- Plant operators were very poorly trained, and what little training they had was inaccurate and incomplete.

A poor understanding of design was also a major contributor to the severe accidents at the Fukushima Daiichi Nuclear Power Plant in Japan in 2011. Major contributing design and safety issues include (Nuclear Reform Special Task Force, 2012; Yasui, 2012):

- Power plants were not designed for such a big earthquake or tsunami. The plant was designed for a 15 foot tsunami. The actual tsunami was 42 feet.
- Site elevation was too low. The diesel generator fuel tanks floated out to sea, leaving the plant without fuel to provide emergency power.
- Plant personnel did not learn from nuclear power industry events (which are globally disseminated), and did not design the plant or safety systems to handle multiple simultaneous problems.
- Poor plant design, especially for the Mark I containment structure. Poor ventilation system and failure to install containment design updates as plants in the United States did.

- Weak safety culture. As an example, cultural tendencies to save face severely hampered and delayed decision making during accident conditions.

Users should not be ignored, especially where human error could be critical, but it is also important to focus on non-human aspects of design (Oliva & Hubbard, 2015).

A general knowledge of other types of user behavior, such as human-computer interaction, technology acceptance or avoidance, information overload and anxiety, and emotional and social aspects of design is beneficial to understanding user research and system design. For example, research has shown that emotions and affect have a role in decision making (Norman, 2004). These studies have generally focused on observation, things, and aesthetics, not cognitive collaborating structures, with an organizational or external concept of performance that is not based on user's uses or effective movement (D'Eredita & Nilan, 2007; Nilan & Mundkur, 2007).

A user-based approach could provide additional useful data and perspectives, as has recently been shown through application of Dervin's Sense-Making approach in new emotionally and aesthetically intensive contexts, such as spirituality and the arts (B. Dervin et al., 2011; Foreman-Wernet & Dervin, 2011).

Finally, human-computer interaction research has made substantial contributions to user behavior research. Some examples include increases focus on the needs of discretionary computer users as opposed to those mandated to use a system or program, attention to individual differences, and support of novice users. The growth of the Internet and graphical user interfaces increased involvement in user testing, but often decreased research rigor for hardware and software to keep pace with explosive growth in the consumer market. By the late 1990s, information sharing and cognitive research (decision making, performance modeling, etc.), and virtualization were new areas of interest. Recently, social networking, web design and marketing, global usability, security, ubiquitous computing, and ergonomics have shown growth in user research (Grudin, 2012).

2.2.4 User Behavior: Concluding Thoughts

It is encouraging that a recent literature review shows that the value of user-oriented research is becoming more widely recognized and is being applied in a broader range of contexts. However, as a result of broader application of user studies, additional areas of concern continue to be identified for research, practice, and theory development, as well as disconnects between scholarly foci of information seeking research and practical challenges in our workplaces and schools (B. Dervin, et al., 2011; Julien & Williamson, 2011; Kuhlthau et al., 2012; Robson & Robinson, 2013).

2.3 Brenda Dervin's Sense-Making Approach

This section explains Brenda Dervin's Sense-Making Approach including: definitions, operationalization, Sense-Making versus the Transmission Model of Communication, and criticisms of Dervin's Approach. Study-specific issues involving the Sense-Making Approach, hypothetical data, and axiomatic design are also discussed.

Dervin's Sense-Making Approach is defined as the cognitive and physical behavior of an individual as applied to cognitive movement through time-space. Individuals adapt or create behavior to address changes in situational conditions as perceived by the individual to make progress toward a goal. Movement is metaphorically defined as a series of steps taken to identify and resolve gaps, evaluate resources, options, or events taken en route to a specific goal. Gaps represent persistent uncertainty as perceived by the user (B. Dervin, et al., 2003b), and are operationally defined as anything the respondent wanted to find out about, was confused about, or was just curious about (B. Dervin, 1983). The concept of curiosity as an information gap associated with information seeking has also been proposed within the field of psychology, viewing curiosity as a feeling of deprivation that motivates an individual to find the missing information (Loewenstein, 1994).

Questions or concerns indicate cognitive gaps the user faces (B. Dervin & Nilan, 1986). "Steps" in this process may involve time-space progress toward the goal, stops in motion, focus on the past, or other types of movement. Steps may identify or ignore identification of any gaps (questions/concerns), and a cognitive and/or procedural action to bridge the gap. It should be noted that ignoring a gap does not close the gap (B. Dervin, 1983). The conceptual framework for Dervin's Sense-Making is based upon Richard F. Carter's work (B. Dervin, 1983; B. Dervin, Chaffee, & Foreman-Wernet, 2003a; B. Dervin, et al., 2003b).

Carter's work discusses and views gaps as a general condition of all systems. When humans perceive a gap and do not know how to bridge it, they stop their current behaviors and develop new behaviors to bridge the gap and reduce discontinuity (Grunig, 2003). Discontinuity is present everywhere, and humans must be able to take steps to move toward a more favorable situation. Steps are the basic unit of human cognitive behavior, consisting of observing (environmental scanning) and moving toward an outcome. Observing provides guidance for moving (Carter, 1980; Kim, 2003b). Richard F. Carter's behavioral molecule describes behaviors in terms of three components: attending, cognizing, and moving (Carter, 1980, 1990a, 1990b; Kim, 2003b):

Attending: Exposing ourselves to the environment, providing an opportunity to encounter a referent, and focusing attention on one thing at a time.

Cognizing: Thinking about the situation and focus of attention to find a way to move.

Moving: Doing something about the situation.

Cognizing can be further broken down into orienting (becoming informed), constructing (building our own instruction), and reorienting (comparing past and present and adjusting movement accordingly) (Kim, 2003a).

2.3.1 Definitions and Operationalization

Gaps – are conceptually defined as anything the respondent wanted to find out about, was confused about, or was just curious about. Conceptually, gaps represent persistent uncertainty as perceived by the user and indicate cognitive gaps the user faces. Gaps are operationalized as questions/concerns, generally referred to as 'questions' (B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986).

Resources – are conceptually defined as information, data, computing functionalities, or links (Nilan, 1992). Resources are operationalized as sources of questions. Data on the basis for questions (why a question was asked or thought about) was collected to provide additional context for the users' questions.

Respondent (or participant) – is conceptually defined as a user, situated in a specific time/space. Respondents are higher education faculty who have had a recent instructional design experience (within approximately the last six months or ongoing).

Situation or Problem – is conceptually defined as the users' situated specific life experience. The situation for this study is a specific recent or significant situation when the user needed to design an instructional experience or instructional materials for any of the following:

- A cross-disciplinary course or lesson
- A topic the user was not very familiar with
- To create a type or means of instruction the user had not tried previously

Sources – are conceptualized as who, what, or where a user finds an answer to a question.

Steps – are conceptually defined as the cognitive behavior of the respondent or others, or events that occurred during the respondents' specific life experience. Steps are not outwardly observable. Steps are operationalized as something you did, something someone else did, or something that just happened (B. Dervin, 1983; B. Dervin, et al., 2003b; Nilan & Mundkur, 2007). Steps provide context for users' questions.

Uses – are conceptualized as the ways that people put answers to their questions to work (B. Dervin & Nilan, 1986). Positive uses are called "helps." Negative uses are called "hurts."

2.3.2 Concepts

While the approaches taken by individuals to bridge gaps may vary considerably, the analysis of a variety of user perspectives to obtain a probabilistic view of reality can identify patterns of information seeking across larger populations. With a representative sample of respondents, this is Dervin's concept of "*circling reality*" (B. Dervin, 1983). From a rational decision-making perspective, this is similar to Marvin Minsky's concept of "view-changing….a problem-solving technique important in representing information, explaining, and predicting." Minsky states that different frames (data structures to represent a situation) of a system represent different options to use information, with choices based on the question "W*hat questions shall I ask about this situation?*" (Minsky, 1995). The focus on cognitive gaps and questions led to application of Dervin's Sense-Making Approach as a means to research question-asking behavior during design for this study.

Dervin's Sense-Making Approach has traditionally been illustrated in terms of a user ("Bob") bridging an information gap to reach a goal, as shown in Figure 3 (B. Dervin, 1992). This is an extremely simplified diagram.

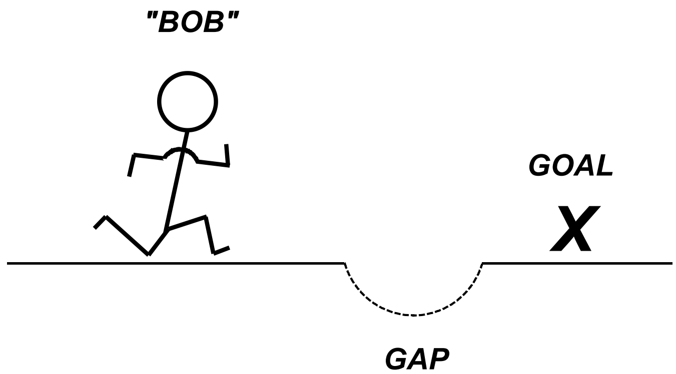


Figure 3. Basic Diagram of Dervin's Sense-Making
Adapted from 'From the mind's eye of the user: The sense-making qualitative-quantitative methodology' by B. Dervin, 1992, in J. D. G. R. R. Powell (Ed.), *Qualitative research in information management*. Englewood, CO: Libraries Unlimited.

Dervin has continued to expand and refine her model. More recent diagrams reflect many more variables as shown in Figure 4.

Analysis of Sense-Making data is based upon identification of patterns of human behavior across respondents. By directly addressing patterns of user needs, based on actual user needs rather than expert-based, hypothetical, or other second-hand estimates of what is useful, a system, approach, or tool can be designed to provide optimal support for identification and resolution of gaps, resulting in improved progress through time-space toward a user's real-life goal (B. Dervin & Nilan, 1986). An objective of this study is to investigate the uses faculty associate with the questions they ask during their conceptual instructional design experience. Dervin's approach is a good fit for that purpose.

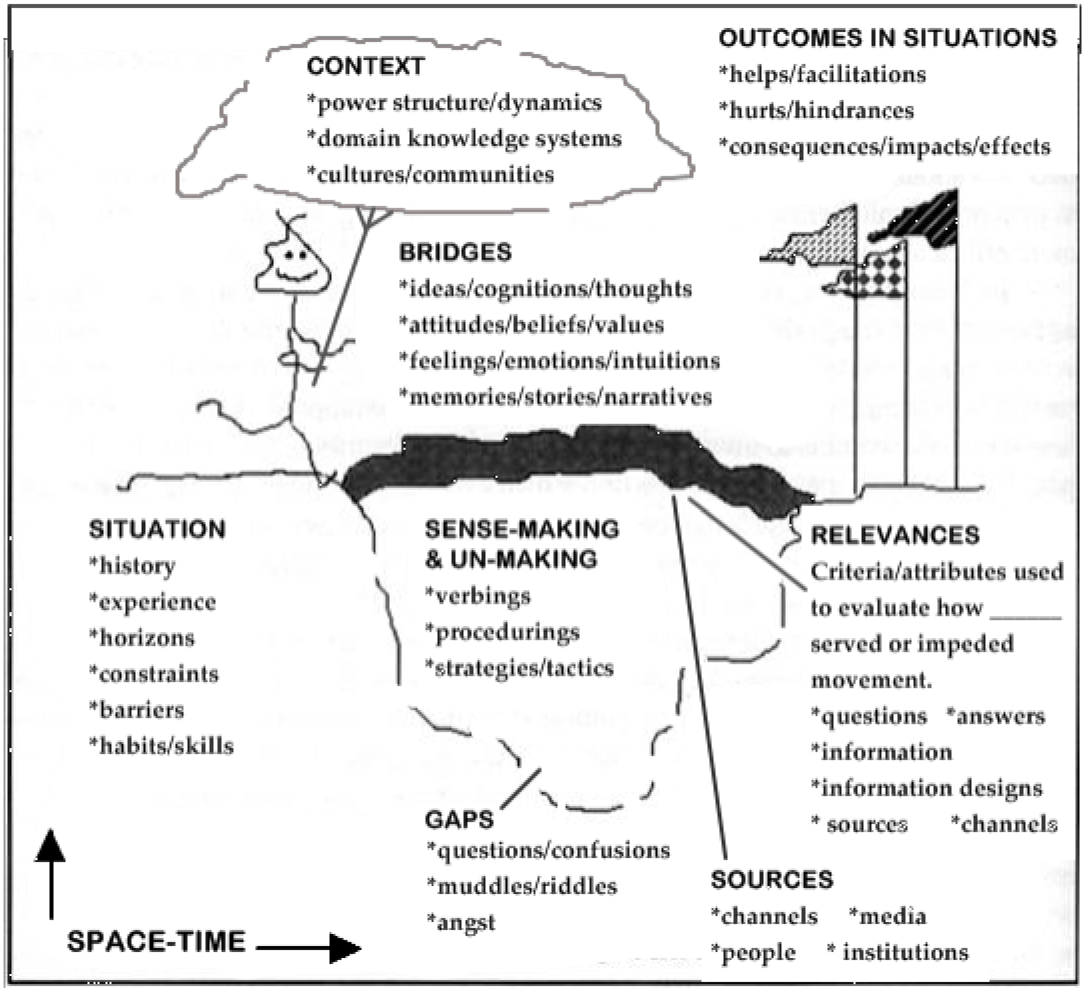


Figure 4. Updated Version of Dervin's Sense-Making Diagram

Adapted from Sense-making the information confluence: The whys and hows of college and university satisficing of information needs, B. Dervin, et al., Editors, Report to the Institute of Museum and Library Services, 2006, School of Communication, Ohio State University, Columbus, Ohio, and the 'Sense-making methodology reader: Selected writings of Brenda Dervin' edited by B. Dervin and L. Foreman-Wernert with Eric Lauterbach. Hampton Press Inc., Cresskill, NJ, 2003.

The following section provides additional background on the distinction between Dervin's Sense-Making and the traditional transmission model of communication.

2.3.3 Sense-Making versus the Transmission Model of Communication

There have been many efforts to better link information sciences models of information behavior with those of communication theory. One of the widest-ranging models is the information-seeking and communication model, which ties together information users, information sources, information products, environmental context, and personal context (Robson & Robinson, 2013). Yet even this model focuses on typical aspects of information research, for example, defining information products in terms of literature, databases, the Internet, presentations, television, and radio.

Dervin's Sense-Making Approach is quite different from the traditional transmission model of communication. Dervin's Sense-Making Approach was developed to investigate information seeking and communicating behavior from the users' perspective, viewing communication as dialogue and requiring listening and accounting for differences in peoples' experiences and understanding (B. Dervin, et al., 2003b). The traditional transmission model of communication is based on a top-down transmission model of a sender sending a message via a communication channel to a receiver. Per Dervin, messages or information based on this model are things to be gotten, similar to throwing something into receivers' heads as if they were empty buckets – a "*tossing bricks into buckets*" metaphor. Typically, the focus is on the message and truth of the message from the senders' perspective. Receivers who do not "get" the message are perceived as deficient, somehow at fault, or otherwise unreachable. Messages are not things to be gotten, but are tied to the life contexts of both sender and receiver (B. Dervin, et al., 2003b). This is a much more dynamic and situational view than the traditional transmission model of communication.

Dervin's Sense-Making is an alternative perspective that views information seeking as a communicative, constructivist, language-based practice in which there is no perspective from which an individual can fully observe reality. Reality and information are constructed by the user with the value of information to the user dependent upon how that information meets the users' needs (Abe, 2005; B. Dervin, 1999; B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986; Nilan & Mundkur, 2007). Dervin's conceptual approach was developed specifically to investigate internal human cognitive processes and is a good fit for investigation of cognitive questioning behavior.

Next, criticisms of Dervin's approach will be examined.

2.3.4 Criticisms of Dervin's Sense-Making Approach

No methodology is perfect. This section discusses criticisms of Brenda Dervin's Sense-Making Approach, focusing on current concerns in several key areas applicable to this study: narrow focus, iteration and complex behaviors, difficulties with implementation, and Dervin's ownership of Sense-Making.

2.3.4.1 Narrow Focus

There have been many criticisms of Dervin's approach, and of information seeking research in general, as focusing too narrowly on active information seeking and searching for systems. Another common criticism is use of readily-accessible populations who are the traditional clients of information science researchers, such as librarians, college students, and other information researchers (Hoffman, 2009; Olsson, 2010), or that sense-making is overly focused on information-seeking (Pollock, 2002). There has also been criticism of sense-making research investigating only part of the domain necessary to identify and address user needs. Hoffman determined that sense-making research on library users to determine how to improve library catalog usage was an inadequate approach. The catalogers in charge of the library catalogs are restricted by current cataloging standards based on a postulated universal user rather than actual users' information needs, and therefore research must also include the catalogers as users and identify and address their needs with respect to cataloging standards (Hoffman, 2009).

This study also focuses on a readily accessible academic population; higher education faculty. This is necessary due to the mandated timeframe of the dissertation research, and because the population involved is a good fit with the background of both the researcher and the dissertation committee, providing grounding for a fairly exploratory initial descriptive research project. However, the focus of the study is on investigating individual question-asking behavior, particularly cognitive behavior of faculty during instructional design. For the purposes of this study, this research context does not require inclusion of investigation of the cognitive designing behaviors of additional players in design experiences of faculty (such as students, subject matter experts, or administrators), but may provide insights on social aspects of designing that could lead to future research. Future research would be expected to include a wider range of individuals involved in the design process.

Pollock suggests that sense-making needs to be more broadly constructed around information behavior rather than information seeking, and that shared knowledge structures are not emphasized as they should be (Pollock, 2002). I agree with this perspective, but it makes sense to want to learn about individual behavior before progressing to shared knowledge structures and behaviors that introduce additional variables and complications. Although Dervin's approach has been under development for quite a while, there are still many areas that have not been investigated even at the individual level, including the question-asking behavior explored in this study.

An interesting pattern among critiques of Dervin's work is that when reading a series of critiques over time, it becomes apparent that many of the problems that have been identified have at least to some extent been addressed by Dervin's ongoing efforts to move sense-making beyond information seeking to a broader model of information behavior. For example, Pollock pointed out in 2002 that "Sense-making has been criticized for being too focused on the individual, and not giving due consideration to the social context," and that at that time Dervin had already been working to reposition sense-making to address contextual issues of power, history, and authority. He later states that although this is progress, the conceptual framework still lags behind Dervin's claims of sense-making as social constructivism (Pollock, 2002). Dervin has continued to work to expand the context of sense-making to include domain knowledge systems, cultures, identities, future goals, social, emotional, and even religious issues, and is also expanding the method to include group interviewing techniques (Agarwal, 2012; B. Dervin, 2010; B. Dervin, et al., 2011). This dedication is impressive, and shows that Dervin does listen to and incorporate the needs of her own community of users, but the conceptual framework still does not seem to have caught up with Dervin's new contextual directions.

The issues of iteration and complex behaviors are possible concerns for this study and are discussed in the following section.

2.3.4.2 Iteration and Complex Behaviors

A criticism of sense-making with respect to investigation of designing behavior is that designing is a very iterative behavior. Information seeking can be iterative, but not to the extent that complex design is. Most sense-making research has involved generally linear information seeking behavior. It is unknown how well Dervin's approach will work for investigation of complex, iterative behavior, but simple iterative behavior has been identified in one of Nilan's studies (Nilan & Mundkur, 2007). Dervin has suggested that sense-making is a more complex and less linear process (B. Dervin, 1999). I think the primary issue here is not with the method. Dervin's approach, when properly applied, can capture iterative information behavior of an individual (Nilan & Mundkur, 2007). For example if someone is doing a web search, changes their mind about the search phrase, and then repeats the search with a minor change to the search phrase. The issue here, as with all design research, especially very complex design research, capturing the cognitive behavior of an individual throughout the entire design process would be a substantial research undertaking. As this study focuses only on the early conceptual instructional design experience of individuals, the scope is small enough that excessive complexity and iteration should not be an issue. It is possible that the use of Dervin’s Approach to investigate question-asking behavior during early conceptual instructional design may reflect little or no iteration at that stage of design. Since it does not appear that anyone has explored this before, this study may be able to shed some value on the appropriateness of Dervin’s approach for this stage of design.

Difficulties with implementation are discussed next, a fairly common concern.

2.3.4.3 Difficulties with Implementation

Other concerns involve implementation of Dervin’s methodology. Similar to ethnographic research, sense-making researchers have reported struggling to deal with emotional investment in the stories of the people they interviewed, becoming quite emotionally connected with the data (Jeffress, 2013; Porter, 2010). It was noticeable that the researchers who expressed this concern tended to include substantial numbers of participant quotes in their published results.

Interview protocols and data analysis can also be problematic. For example, one researcher reported encountering difficulties during pre-testing of sense-making interviews when respondents struggled with defining the questions they had during the tricky or difficult parts of the life experience they were describing. This difficulty occurred because the researcher had operationalized gaps too narrowly as questions only. Once the protocol was revised to include both questions and constraints (“something that caused you to pause”), respondents were better able to articulate their experiences with confidence. Problems were also encountered during data analysis when some results were not as anticipated, in part due to researcher inexperience with design and implementation of sense-making interviews, and in part because the researcher had made an assumption about what the nature of the resources would be (Deitz, 2011).

With education and practice, Dietz applied Dervin's approach appropriately and was knowledgeable enough with sense-making to identify the causes of difficulties with implementation and assumptions, taking appropriate steps to resolve concerns. However, there can be a tendency for implementation of sense-making as a method without an adequate understanding of the overall conceptual framework. Sometimes researchers dive into the sense-making methodology without either appropriate education or practice, combining various flavors of Dervin's approach in what has been referred to as a "cheap and cheerful fusion of methods and models" leading to "mash-ups that result in studies that are conceptually and theoretically inconsistent" (Davenport, 2010).

Finally, Dervin's ownership of Sense-Making is covered.

2.3.4.4 Dervin's Ownership of Sense-Making

It has been suggested that the ownership Dervin holds of sense-making, plus sense-making's highly specialized ontology, may present barriers to collaborations needed to refine and evangelize the viewpoint. Dervin's tendency to avoid focus on system rather than users has also been pointed out as a potential obstacle (Pollock, 2002). On the other hand, Dervin is acknowledged as a guru of sense-making (Olsson, 2005), having developed one of the most cited and broadly used models of information behavior, and continually working to improve the model and expand the sphere of research.

Brenda Dervin's Sense-Making Approach is not straightforward to understand. Sense-making interview techniques require time, practice, and patience. There are valid conceptual and implementation concerns, some of which appear to be more due to lack of understanding of Dervin's approach than to weaknesses in the approach itself. Dervin's approach can be very valuable when it is well understood and appropriately applied and analyzed. The lack of a readily available and comprehensive 'Sense-Making 101' guide on meta theory, methodology, and method is noticeable, and may contribute to misunderstandings of Dervin's Sense-Making Approach.

2.3.5 Study Specific Issues

This section discusses study-specific issues involving the Sense-Making Approach, hypothetical data, and axiomatic design.

2.3.5.1 Hypothetical Data and Design

Dervin's approach takes the perspective that user-based data is valid when based upon the actual life experiences of users, as opposed to hypothetical data based upon simulations, speculation, observation, or other indirect means of data collection.

Although I agree with this perspective in general, I believe that there are circumstances in which use of hypothetical data during design is acceptable. Specifically, hypothetical data is acceptable during the conceptual stage of design if there is no other reasonable means of obtaining user data, and if all reasonably possible steps are taken to verify or refute that data by involving users throughout the entire design process. Design is used to build validity by systematically including users in design throughout (Oliva & Hubbard, 2015).

We learn from hypothetical data often. How many of us have learned valuable moral lessons from fairy tales or nursery rhymes as children? Fairy tales and nursery rhymes are definitely hypothetical data, but that doesn't mean we can't learn from them. The difference with design is that poor design may be based on initial hypothetical data which is never verified or refuted as design progresses. Frequently this occurs because users are not systematically involved throughout the design process. As long as designers are aware that initial data based on new ideas is hypothetical and must continue to be addressed as design progresses, initial hypothetical data should not be a serious concern (Oliva & Hubbard, 2015).

Sometimes design may be performed based entirely on hypothetical data. An example is the Dyson Sphere, a cosmic mega structure first proposed by Freeman Dyson, and inspired by earlier science fiction. A Dyson Sphere is a solar collection shell erected around a star to capture the maximum amount of solar energy for human use. Scientists disagree on whether a Dyson Sphere could realistically be built based on current or future technological advances, but concept has spawned other more feasible ideas. An example is the Dyson Swarm, a collection of small individual solar collectors/converters orbiting a star (Dyson, 1960; Hadhazy, 2014).

When a designer has a new idea and no way to create a prototype without first getting input from someone (for example, the boss won't provide budget to begin conceptual design until proof of need is provided), there is little choice but to begin based upon hypothetical data. It's not the initial data that is necessarily the issue – it's what's done about the data from then on (Oliva & Hubbard, 2015).

As an example in the context of instructional design, hypothetical data on student needs may be used to develop a lesson if no actual data is available. It would be expected that any mismatches between hypothetical needs and actual needs would be actively sought out and resolved when the lesson is taught. Preferably, needs analysis could be performed with the actual students prior to teaching the lesson.

The next section discusses applicability of Dervin's Sense-Making approach with respect to axiomatic design.

2.3.5.2 Dervin's Sense-Making Approach and Axiomatic Design

Dervin's Sense-Making approach is very appropriate for investigation of the types of design cognition issues that design researchers are currently interested in, particularly within the axiomatic design community. Design researchers in the axiomatic design community, at the cutting edge of design research, have expressed high levels of interest in learning more about question-asking behavior during design, human coping mechanisms for information overload, better understanding the creative design process, communicating design ideas, teaching design-related critical thinking skills (the need for bi-modal designers capable of both analysis and synthesis), and understanding the cognitive aspects of the design process across design disciplines (Rothwell, 2013; Suh, 2013). Dervin's Sense-Making interview techniques are a proven means of eliciting implicit cognitive actions of users, as is needed to help demystify the complexities of design thinking and creativity, and identify patterns of designer behavior across design disciplines. This is a new and exciting research direction.

2.3.6 Dervin's Sense-Making Approach: Concluding Thoughts

We really don't know what to expect when Dervin's approach is applied to the initial portion of a complex behavior like design. The researcher has been trained on Dervin's Sense-Making Approach, and has performed several sense-making research studies including one that analyzed data for approximately 70 participants, providing necessary research experience for application of Dervin's methodology in this study. A side benefit of this study is the opportunity to provide insights on the use of sense-making to explore part of a larger complex, iterative behavior.

2.4 Instructional Design and Technology

This section discusses the definition of the field of instructional design and technology; key research findings, current issues and study-specific concepts.

2.4.1 Defining the Field of Instructional Design and Technology

The field of instructional design and technology is the context for the proposed dissertation research. The field has been redefined by the Association for Educational Communications and Technology seven times since 1963. I will refer to the field as instructional design or instructional design and technology, using Reiser's current definition (R. A. Reiser, 2012):

> *"The field of instructional design and technology (also known as instructional technology) encompasses the analysis of learning and performance problems, and the design, development, implementation, evaluation, and management of instructional and non-instructional processes and resources intended to improve learning and performance in a variety of settings, particularly educational institutions and the workplace.*

> *Professionals in the field of instructional design and technology often use systematic instructional design procedures and employ instructional media to accomplish their goals. Moreover, in recent years, they have paid increasing attention to non-instructional solutions to some performance problems. Research and theory related to each of the aforementioned areas is also an important part of the field."*

Performance and learning technologies, multimedia and technical documentation development, hardware and software development, knowledge/change management, and online learning often overlap with instructional design.

For example, consider the design of complex computer-based training applications for new technology, such as wireless radio frequency communications systems that use radios connected to computers to transmit email and attachments long distances by radio. Users are in remote locations and require immediate training for novices and experts in online and mobile formats. This requires developing computer-based instruction in parallel with systems design. The radios are complex software-driven products that interface with a variety of computers and operating systems. Designing instruction requires configuration management skills, knowledge of user behavior and needs, knowledge of information systems and performance technology, technical writing skill, and competence with design of multimedia environments (simulations of radio operation), online learning, security and safety issues, and the expectations, abilities, and technological savvy of students of all ages and backgrounds.

Instructional design is a huge field with a substantial amount of literature. This section outlines pertinent research findings, current issues, and several topics specific to the study: expertise, dissemination of practice, motivation, and curiosity, instructional design as design, and the need for improved support of instructional design.

2.4.2 Key Research Findings and Current Issues

Research in instructional design is extensive and often overlaps with educational research. A current issue of specific interest for this study is designing instruction to teach design. Panels and discussions at the 7th International Conference on Axiomatic Design (ICAD) and the 2nd International Workshop on Design in Civil and Environmental Engineering in June 2013 stressed the need for better ways to teach students design and help students learn to ask better questions during design. This is an issue that needs to be addressed at all levels of design education, from pre-K and K-12 through graduate and professional education (Rothwell, 2013).

David Merrill (Merrill & Wilson, 2007) has a perspective on the future of the field that is specifically applicable to my interest in instructional design tools for novice users. He asks whether we need to acknowledge that instructional design is and will continue to be performed by designers-by-assignment (those assigned to do instructional design without formal training as an instructional designer), and shift our activities from training instructional designers to the study of instruction and creating instructional design tools that allow everyone to be more effective designers of instruction. He states that 95% of all instructional design is done by designers-by-assignment, and many instructional products fall very short of their potential. In addition, he believes that:

"Formulating and verifying effective design theory is merely an academic exercise unless this theory is transformed into tools that provide intellectual leverage (p. 340)."

We need to learn more about the cognitive behavior of instructional designers. Research findings can be located to both support and deny the success of almost any instructional approach, learning theory, and classroom environment, but we really do not know why there is not more consistency across these issues. In part, this is probably due to the tremendous number of variables involved in educational research, which makes any type of user research in an educational environment very difficult. There are also multiple user roles to consider: the designer, the teacher (designer/teacher may be the same individual) and the student. In the usual educational environments, there are many students for each teacher, further complicating issues. Materials and methods that work well in one classroom may not work very well at all in another classroom, and we often do not know why, or how to predict what will work in any given situation (Yacci, 2007). User-based research may help with this by providing more insight on instructional designer's perspectives. Investigating instructor's question-asking behavior during instructional design may contribute to our understanding of the cognitive behavior of faculty during instructional design.

2.4.3 Question-Asking and Instructional Design

This study examines question-asking behavior of faculty during the early conceptual stage of instructional design. There are many situations and issues other than conceptual instructional design that involve question-asking behavior and instructional design. A comprehensive discussion of question-asking behaviors, situations, and instructional design is beyond the scope of this dissertation; however, Table 1 outlines some of the more common issues involving instructional design and question-asking.

As many higher education faculty design instruction and teach, question-asking related to both instructional design and teaching is included. While we know a lot about the types of questions that are commonly asked externally during instructional design, or that are specific to a selected instructional design model, we don't know much about cognitive behaviors involved in question-asking during instructional design. Investigating questions asked during conceptual instructional design may provide insights about issues such as initial decision-making for selection of an instructional design model or strategy, or difficulties trying to determine initial design direction. This aspect of the study is likely to validate some of what we already know about instructional design and identify areas of difficulty and directions for professional development and future research. Reflective self-questioning may provide some of the most interesting study data, as indicated by pilot testing. Question-asking during instructional design may typically be guided by any combination of the following:

- The instructional designer (focus of the proposed research)
- Learner/needs analysis
- Various instructional design models, processes, or guidelines such as Mager's performance analysis approach or Allison Rossett's guidance on task analysis (Mager, 1997; Rossett, 1987).
- Input from or observation of subject matter experts
- Input from or observation of novices, often using think-aloud protocols

Table 1. Question-Asking and Instructional Design*

Designer's Situation	Purpose of Question-Asking	Concerns or Issues	Recommended Reading
Front-end Analysis	To determine learner needs prior to beginning design of instruction. May incorporate audience analysis, needs analysis, performance analysis, task analysis, and job analysis. The primary focus is learners, however external requirements and expectations are often incorporated.	Who is the audience? What are their needs. How to determine needs versus wants? What type(s) of analysis do I need to do? External organizations, requirements, or individuals to include? What is the expected performance? What are the priorities? How do I do all this?	Mager, R. F. Analyzing Performance Problems (1997). Rossett, A. *Training Needs Assessment* (2nd ed., 1987). Zemke, R., & Kramlinger, T. *Figuring things out: A trainer's guide to needs and task analysis* (1982).
Working with Experts	To determine experts' needs for instruction, or to distinguish between expert's approaches and what instructional approaches would be best for novices.	How do I take the characteristics of human cognition into account to design instruction for experts? What needs to be different for instructing novices?	Kalyuga, S., et al. The expertise reversal effect (2003). Spector, J. M. Expertise and Dynamic Tasks (2008). Davidsen (Eds.), *Complex Decision Making* (pp. 25-37): Springer Berlin Heidelberg.

Designer's Situation	Purpose of Question-Asking	Concerns or Issues	Recommended Reading
Meeting with Subject Matter Experts (SMEs)	To obtain information about a topic the designer is not familiar with. May include observing and recording activities, determining sequencing, concepts, content, risks and safety issues, materials or context, potential difficulties, etc.	Learning new things & simultaneously trying to capture explicit and tacit knowledge (video, observation, talk-aloud, document analysis, etc.) and ask good questions. Shared vocabulary may be minimal for a given topic. How to effectively question an SME?	Michael Keppell: *Principles at the heart of an instructional designer: Subject matter expert interaction* (2000)
Determining Teaching Techniques	To identify potential teaching approaches that will engage and motivate students, and support students as they learn. To determine learning environment constraints and adapt teaching methods accordingly, including ways to communicate and share ideas and expectations. To provide the teacher with tools and means to best teach content.	How to present? What if things go wrong? Student interactions? Hands-on? Feedback timing & methods? Online, classroom or other learning environments? How to develop a rapport with students? First day of class issues? In-class activities, technologies, and expectations? How to motivate/engage students? How do I choose a technique to use? How do I figure all this out?	John Keller's ARCS Model Merrill, M. D.: First Principles of Instruction Merrill, M. D.: *Instructional Strategies That Teach* (2000) Roger Schank: *What We Learn When We Learn by Doing* (1995) Keyser: *Active Learning and Cooperative Learning* (2000) R. Small and M. Arnone: Make a PACT for Success (2002)

Designer's Situation	Purpose of Question-Asking	Concerns or Issues	Recommended Reading
Meeting with Novices	As Users: To determine what novices do and don't know about a topic, and what they need. Necessary to determine appropriate level of instruction and content. As Instructional Designers: To provide mentoring and instruction.	Novices don't know what they don't know, and don't know what questions to ask. Shared vocabulary may be minimal for a given topic.	Perez & Emery: *Designer Thinking: How Novices and Experts Think About Instructional Design* (1995). Kirschner & van Merrienboer: *How Expert Designers Design* (2002)
Evaluating and Assessing Student Learning	To determine the extent of student learning and how student performance compares to defined expectations.	What questions to ask, determining conditions, criteria, and performance, matching test items & learning objectives, grading policy, appropriate & timely feedback, tying learning objectives to Bloom's taxonomy (cognitive process and knowledge dimensions). How can I really be sure students are learning? How do I do all this?	Robert F. Mager's Preparing Instructional Objectives (1997). Bloom's Taxonomy: see David R. Krathwohl's *A Revision of Bloom's Taxonomy: An Overview*

Designer's Situation	Purpose of Question-Asking	Concerns or Issues	Recommended Reading
Coping with Instructional Technology	Evaluating technological and media options. Determining how to use or troubleshoot instructional technology, or assist students with classroom technology.	How do I use this, how does it work, what are the possibilities for design and instruction, and what do I do when it doesn't work? Copyright, plagiarism, privacy.	Gillespie, F. (1998). Instructional design for new technologies. *New Directions for Teaching and Learning, 76*, 39-52. Dodge, Bernie (2007). The WebQuest Model. Webquest.org
Classroom Interactions with Students: Questions to Ask Students, and Questions Students May Ask	To find ways to engage and motivate students and determine if students understand what is taught. To be prepared and have answers or alternative approaches if students have questions. Novices ask different kinds of questions than experts. As a designer: To anticipate what a teacher will experience in the classroom and develop appropriate materials and teaching options.	The process of asking/answering questions, timing of questions, classifications of questions/answers, whether alternative questions or answers are provided, appropriate vocabulary, what questions to ask to motivate/engage students, how to encourage students to ask questions, the safe classroom, encouraging student interaction.	Frischknecht and Schroeder: Asking Smart Questions (2006) Nancy Johnson-Farris: Questioning Makes the Difference W. McKeachie: McKeachie's Teaching Tips

*Table validated by a prior Finger Lakes Faculty Development Network member (Bonzi, 2015).

It should be noted that there are many instructional design models, processes, and guidelines available, some of which are highly customizable. An advantage of this is that guidance can be found for almost any design or instructional situation. Disadvantages are information overload and adopting one or two approaches and molding everything else to fit that approach, often with inappropriate results. A classic example is a teacher who does everything using PowerPoint(Yacci, 2007).

The next section discusses motivation curiosity, and self-efficacy.

2.4.4 Motivation, Curiosity, and Self-efficacy

It seems reasonable to expect instructional designers to consider ways to motivate students as they design instruction, but we don't know to what extent faculty may consider motivational factors. If novice faculty do not think about motivational factors to any real extent during instructional design, that could be an important focal area for future research and design of instructional design support systems.

Attention to motivation and related concepts such as relevance, interest, and curiosity is important for determining instructional design strategies, developing instructional materials, and contributing to sustained learning (Keller, 1983). Yet presentation of information in and of itself does not ensure effective instruction or meaningful learning outcomes. Information, instruction, and learning are interrelated, and instruction is more likely to be successful if learners are engaged and motivated (Small, 2004). Motivation is the root of the desire to learn. As Roger Schank has said; "People are ready to learn when they realize that they don't know something that they needed to know in order to accomplish a goal they wanted to accomplish" (Thompson, 2013).

Curiosity also plays a role in motivation, and is tied to attention, relevance, confidence, and satisfaction (Arnone & Small, 1995), and may be influenced by technological and social context (Arnone, Small, Chauncey, & McKenna, 2011), possibly impacting question-asking behavior.

Research on the role of self-efficacy in engineering education indicates that teaching coping strategies can help to develop self-efficacy (Ponton, Edmister, Ukeiley, & Seiner, 2001). Practical experience in the nuclear power industry supports the idea that improved questioning skills can increase the possibility that users will realize they need to learn more about something to effectively accomplish a goal, and may help motivate users to perform systematic questioning during design. Improving question-asking skills may be one means to help designers cope with the complexity of design and increase self-efficacy with respect to designing.

Keeping motivation in mind is critical for designing effective instruction. The expectancy-value theory of motivation, which states that motivation to accomplish a task is based on an individual's belief that the task has value and he/she is expected to accomplish that task (Wigfield & Eccles, 2000), applies to faculty and to students. Faculty need to design instruction and instructional materials to convince students that a task is valuable and that the student is capable of successfully accomplishing that task (i.e. improving self-efficacy, an individual's self-judgment about personal capabilities (Bandura, 1977). Faculty need to believe in the value of their own instructional design and instructional activities, including the value of question-asking during design. This study investigated faculty perceptions of the value of their question-asking behavior by asking several big-picture questions of participants, such as what they feel is most important about questions to ask during instructional design (refer to section 3.8.1.1.5). This study is based in part on the need for improved instructional design support.

2.4.5 The Need for Instructional Design Support

In the early stages of instructional design, especially for unfamiliar content or domains, even the most experienced instructional designer may essentially be a novice user, often with no realistic means of effectively involving students. A realistic compromise is to attempt to create the best possible instructional materials that time and budget allow the first time around. This reduces redesign and the potential for confusion or failure when first taught. Improved questioning early in the instructional design process can improve the chances of identifying and addressing student needs and instructional design problems up front (Oliva & Hubbard, 2015).

It may seem to be somewhat of an epistemological paradox to perform user-based research on the behavior of faculty during early phases of instructional design, prior to interaction with students, who are the end users, but this is due to the nature of instructional design in higher education and is not quite the paradox it may seem.
It is very important to incorporate student perspectives into design whenever possible. Optimally, instructional design and associated information seeking would be a dynamic process involving instructional designers and instructors, students, subject matter experts, and other stakeholders throughout the entire design process, but this does not always happen. Higher education faculty who are tasked with instructional design very rarely have time or budget available to involve potential student users in instructional

design, nor do they generally create or accumulate complete instructional materials early in the instructional design process, or necessarily know what information is needed or what actions to take. Even if instructional design involves students throughout, that does not guarantee future student learning. Redesign is required for each new learner or set of learners, either in advance or on the fly as questions and issues arise during instruction (Yacci, 2007).

Instructional design in academia does not/should not stop when a lesson or course is designed. Instructional design continues, sometimes on the fly in the classroom, as new student needs are discovered, unanticipated events occur, or materials or teaching methods fail to match expectations.

In conclusion, these are some of the challenges that faculty may face as instructional designers who also teach:

- As many as 95% may be designers by assignment with little or no formal training on instructional design (Merrill & Wilson, 2007)
- Even the most expert designer can be a novice in a new domain (Cross, 2004; Ericsson & Lehmann, 1996; Oliva & Hubbard, 2015)
- Lack of useful tools to support instructional design (Boling & Smith, 2012; Rowland, 1992)
- Adjunct instructors may lack opportunity for professional development (Scott, 2014)

- The need to adapt instruction on the fly, which requires a level of expertise at both teaching and instructional design (Yacci, 2007)
- A field with a history of poor dissemination of research results and best practices (Ellis, 1986; Scott, 2014; Yacci, 2007)
- An environment that generally results in design and development of instruction without the opportunity for user testing prior to implementation in the classroom (Yacci, 2007)
- An apparent disconnect from design research in other design fields (Rowland, 1993)
- Coping with new technologies inside and outside the classroom, and associated evolving student expectations (Totten & Schuldt, 2009)
- The pressures of a tight economy mean instructional design and instruction need to motivate, engage, and retain students, getting things right the first time around, typically with fewer resources and less prep time available (R. A. Reiser & Dempsey, 2012; Tully, 2013).

It is apparent that there is a need for improved support of instructional design, particularly for designers by assignment. This study will contribute to our understanding of the needs of faculty performing instructional design, providing a basis for developing additional support.

The next section discusses concerns regarding dissemination of practice.

2.4.6 Dissemination of Practice

An ongoing issue in the field of instructional design is the dissemination of practice to academia. Instructional designers, designers-by-assignment, and instructors tend to try various approaches to instructional design. When they find something that works, they continue to use it, but often without determining why their solution works, and without sharing their successes with academia (Yacci, 2007). The current trend toward increasing use of adjunct instructors is most likely further complicating this issue, as many adjunct instructors do not have the opportunity to participate in professional development or in academic life other than in the classroom (Scott, 2014).

This study will disseminate the results of the dissertation research via dissertation publication, journal and conference papers, and provision of results to participants, participating institutions, and the axiomatic design community.

The following section covers study-specific concepts.

2.4.7 Study-Specific Concepts

This section discusses the study-specific concepts of instructional design as design and questioning techniques and cognitive loading. These topics support the concept of design as a discipline and benefits of question-asking, respectively.

2.4.7.1 Instructional Design as Design

The perspective taken for this research is that instructional design is a design field in much the same way that engineering and architecture are design fields (Oliva & Hubbard, 2015). This perspective is supported by design science research findings, as shown in the Design Studies column of Table 2. Design Fields Comparison (Cross, 1998, 1999; Eastman, 2001; Eris, 2004; Lloyd, Lawson, & Scott, 1995), which compares design science research findings with instructional design. It is apparent from this table that instructional design fits the characteristics of design as defined by current design science research.

Table 2. Design Fields Comparison*

Design Science	Instructional Design ("Yes" indicates a parallel with Design Science)
Requires defining the design context (system, physical, social, cultural, and environmental)	Defining the contexts of instructional design, instruction and learning
Examination of the design from multiple perspectives	Yes - audiences, content presentation, instructional media and methods, etc.
Generation of multiple alternatives	Yes – media, content, instruction, etc.
Formulating critical performances	Yes – learning outcomes, grading schemes, etc.
Mental construction of a design world (includes mental simulations)	May occur, depending on the subject area and educational needs
Social cognition	Yes, both by designers and as an aspect of student learning to be considered
Designers use a variety of methods	Yes – many design and instructional methods and models exist
Experts emphasize keeping design and solution space open, and asking different questions to gain insight into the space of possible designs	There is very little research in these areas, but expert instructional designers in the nuclear power industry emphasize these issues.
A need for convergent and divergent questioning.	Yes – for new or modified subject matter, or to modify existing instructional materials or methods to fit a new situation.
Design involves finding and solving appropriate problems, and includes substantial activity in problem structuring and formulating.	Yes – for new or modified subject matter, or to modify existing instructional materials or methods to fit a new situation.
Constant generation of new task goals	Yes – likely for new or modified subject

Design Science	Instructional Design ("Yes" indicates a parallel with Design Science)
and redefinition of task constraints.	matter, materials/methods, or situations.
Co-evolution of problem and solution: designers use solution conjectures to develop their understanding of the problem. The problem can't be fully understood in isolation from consideration of the solution.	Yes – likely for new or modified subject matter, materials/methods, or situations.
Design is exploratory and emergent	Yes – likely for new or modified subject matter, materials/methods, or situations.
Design is opportunistic – all relevant information cannot be predicted and established in advance of design.	Yes – likely for new or modified subject matter, materials/methods, or situations.
Design is abductive rather than inductive or deductive	Yes – likely for new or modified subject matter, materials/methods, or situations.
Design is ambiguous and risky	Yes, especially considering the substantial number of variables involved in any educational situation.

*This table was constructed from literature (Edwards, 1973; Gagne, Wager, Golas, & Keller, 2005; Horton, 2001; Jonassen, 2004; Kolko, 2010a; Liu & Lu, 2013; Reigeluth, 1983; R. Reiser & Dempsey, 2007a; Suh, 1990). Instructional design and nuclear power industry practices were validated (Bonzi, 2015; Oliva & Hubbard, 2015).

Unfortunately, literature review indicates that the field of instructional design is not generally considered a design field in the same way as engineering, architecture, or art (Rowland, 1993; Scott, 2014). A broader view is taken in U.S. commercial nuclear power (Oliva & Hubbard, 2015).

2.4.7.1.1 The Nuclear Power Perspective

Instructional design is definitely considered a design field in commercial nuclear power in the United States, and is treated very similarly to engineering design. This supports the concept of design as a discipline, and is implemented via a systematic approach to design (Oliva & Hubbard, 2015).

The concept of a systematic approach to education/training and design is not unique. It has a long history in the field of instructional design. However, the concept of addressing instructional design in the same way as engineering design on a daily basis (a systematic approach to the discipline of design across design domains) may be unique to nuclear power (Oliva & Hubbard, 2015). The closest similar approach identified during review of the instructional design literature is that of Alex Romiszowski's *Designing Instructional Systems* (1981). While other organizations and individuals rarely have to perform at the extremes necessary in the nuclear power industry, and Rickover himself admitted that his way was not the only way of doing things (M. Aurisicchio & Bracewell, 2013). It is a proven approach from which much can be learned.

2.4.7.1.2 Moving Toward the Idea of Design as a Discipline

No discussion of instructional design research within engineering design studies has been located, but there has been some discussion of engineering design research within the instructional design field. For example, Gordon Rowland reviewed engineering design studies and made comparisons with instructional design research. He concluded that (Rowland, 1993):

- Instructional design literature describing and prescribing instructional design processes is based largely on experts' opinions and recollections rather than on systematic investigation.

- Instructional design literature tends to view the field as a deterministic set of procedures to be followed. There are concerns that this view may not reflect what instructional designers actually do. Practice often differs substantially from common views of how instruction should be designed.
- There are clear similarities between instructional design and other fields of design.

Rowland has also investigated what instructional designers actually do. He feels we need to develop instructional design tools to help non-designers and novices, that some current educational efforts may be teaching instructional designers to follow procedures rather than to ask good questions, that tools need to better reflect the realities of practice, that research needs to investigate why decisions are made, that a list of questions to ask could be a helpful tool feature, and that novices need guidance on good questions and use of multiple perspectives (Rowland, 1992). More recently there has been some cross-discussion between instructional design researchers and design science researchers (M. Aurisicchio, Bracewell, & Armstrong, 2012). One of the difficulties with designing is that people in a design role may not always be aware that they are doing design, and therefore are less likely to follow principles and processes that have been shown to assist with effective instructional design (Merrill & Wilson, 2007). These findings reflect my beliefs about instructional design.

The field of instructional design is beginning to move toward investigation of design as a whole to include all aspects of improving learning and performance, with increasing interest in determining the true nature of what instructional designers do. While the majority perspective appears to continue to be process and model-oriented, more attention is being paid to moves to expand the view of design within the field (Boling & Smith, 2012).

In the current edition of *Trends and Issues in Instructional Design and Technology (R. A. Reiser & Dempsey, 2012),* Boling and Smith discuss of the changing nature of design, from process models to the idea of instructional design as a fully developed system of inquiry for educational contexts, and then to a tradition of design involving knowledge building, principles, heuristics, and problem-solving, with design language and aesthetics. Boling and Smith state that instructional design is not a science, and that experts do not use the tools for design that scholars develop and teach in this field (process models and prescriptive theories), and when used as a primary vehicle for teaching such tools may actually defeat the development of design expertise (2012). This shows some progress toward an understanding that there is a larger realm of design that is deserving of study. However, it is still far from grasping the concept of design as a discipline, with a scientific basis for design and a systematic approach to design, whether engineering, instructional, or other.

The next section discusses questioning techniques and cognitive loading, an aspect of the benefits of question-asking during design.

2.4.7.2 Questioning Techniques and Cognitive Loading

Researchers have recently begun to investigate issues involving expertise and cognitive load theory-based instructional strategies to examine how insights from deliberate practice by expert performers can be adapted and incorporated into instruction and training of novices (van Gog, Ericsson, Rikers, & Paas, 2005). This research provides background that could be helpful for future research on whether questioning techniques used in nuclear power can help to reduce cognitive loading in the same way that sketching has been shown to reduce cognitive loading for engineering designers.

Research has shown that sketching reduces cognitive load, compensates for limitations in mental imagery, supports iteration, helps designers notice new, emergent elements of a design, and enables designers to handle different levels of abstraction simultaneously (Bilda & Gero, 2007; Cardella, Atman, & Adams, 2005; Cross, 1998). Sketching is used to identify and then reflect upon critical details, details that they realize may hinder or significantly influence the final implementation of the design, and enabling identification and recall of relevant knowledge (Cross, 1998). It is a common notion among designers (and artists) that if they could say what they were attempting to do they wouldn't have to design/draw/compose it (Lloyd, et al., 1995). As an example, a question bank can serve a similar function during design, helping designers with both divergent and convergent thinking (Oliva & Hubbard, 2015).

The next section discusses the field of cognitive science. As this study investigates aspects of human cognition during designing, an understanding of selected aspects of cognitive science is helpful.

2.5 Cognitive Science

The field of cognitive science (refer to section 1.3) was formally founded in 1976, encompassing a range of fields and disciplines that study human thinking, mental processes, memory, intelligence, expertise, motivation, perception, mental representation, and learning (Stolovitch & Keeps, 1999; Davies, 2005), as well as connectivist theories that model thinking using artificial neural networks (Stanford, 2004). This section outlines key concepts within the field of cognitive science that are most closely associated with the conceptual framework for this study: mental representation, novice/expert issues and problem solving.

2.5.1 Mental Representation, Sense Making and Instructional Design

The means by which the human mind creates, accesses, and stores mental representations is an ongoing subject of debate in the field of cognitive science, as well as in psychology, neuroscience, neuropsychology, learning science, and other fields. Familiarity with theories of memory and representation is helpful because our cognitive designing behaviors are supported by our ability to mentally create, access, and store information.

There are many different theories about how we represent, learn, and remember. Current theory development associated with mental representation has been greatly influenced by new technology that permits improved analysis of brain function and neural activity, with a focus on how the brain creates mental models and the concept of embodied cognition. Embodied cognition is a holistic perspective on cognition, the idea that states of the body, senses, and interactions with the environment can affect the state of the mind (Thagard, 2010; A. D. Wilson & Golenka, 2013). The concept of embodied cognition is interesting, as it supports the idea that interacting with technology changes the way we think (Kirsh, 2013), a perspective that has been part of nuclear power safety culture since the Rickover era (Oliva & Hubbard, 2015).

Representation is still largely an open issue, requiring more investigation both from theoretical and practical perspectives. This literature does not provide direct insight into the cognitive processes of instructional designers, but it does provide a tie to the proposed research methodology. A user situated within a specific life situation or problem takes cognitive steps (moving) to seek information, determine representing options (representations), and decide which representing option to use and how to present that representing option. The user tries to find ways to move forward (though not necessarily linearly) toward a goal. Questions and concerns are ways of representing gaps, the uncertainties in the user's situation, and attempting to make sense of things.

Identifying and addressing instructional design problems also involves representing behavior. The way an instructor represents problems and solutions through use of rules, concepts, analogies, etc. ties closely to effective presentation of that information and the student's own interpreting of the ideas taught (student's attempts to represent). Instructional designers/instructors need to both make sense themselves of what they want to design/teach, and look at how their students can make sense of the instruction and instructional methods and materials.

Making sense of things frequently involves asking questions. The ability to self-question and to know what questions to ask others is important for determining how to represent a specific problem or topic within a given context. Everyone can design, and everyone can self-question – but not everyone can design well, and not everyone can effectively question within a specific design context. This study may provide insights on problems faculty encounter when determining what questions to ask.

The next section discusses novice/expert issues.

2.5.2 Novice/Expert Issues

Novice/expert issues come into play within this study as a factor in instructional design decisions. For example, research has shown that experts can be expected to have substantially more domain knowledge than novices, ask more and higher quality questions, and more consistently make good design decisions (Miyake & Norman, 1979; Rowland, 1992). Novices do not ask many questions when material is very difficult, and do not appear to be able to cope with situations that are too far outside their present level of knowledge (Miyake & Norman, 1979; Rowland, 1992).

It is anticipated that involving faculty who are both novice and expert at performing instructional design in this study will provide a range of identified information needs and insight on ways to better support question-asking during conceptual instructional design. It may also provide opportunity to compare the design approaches of faculty who are both novice and expert at performing instructional design.

Instructional designers who are conscientious about learning about a new subject or topic thoroughly when they are involved in an instructional design project are frequently in a novice role (Yacci, 2007), and may be more likely to try and deliberately think like a novice. It may be that regular practice at being a novice during instructional design and development could contribute to a tendency for instructional designers to ask more novice-level questions in a new information-seeking situation, sensitize them to novice issues, or contribute to an improved ability to communicate with novices. This does not replace involving users in the design process, but complements user involvement, especially for complex design in situations where full testing is not possible prior to implementation, where design outputs do not have an existing user base, or where the user base is too small and specialized to provide a range of design input (Oliva & Hubbard, 2015).

It may sometimes be possible to train an expert to think more like a novice when designing materials, tools, or systems to be used by novices (Oliva & Hubbard, 2015). There appears to be little literature on this issue, but Albert Cullum has stated that a teacher should remain a novice, and that remaining a beginner is the first step toward truly seeing the students sitting in front of you (Cullum, 1967). It may be that regular practice at being a novice during instructional design could contribute to a tendency for instructional designers to ask more novice-level questions in a new information-seeking situation, sensitize them to novice issues, or contribute to an improved ability to communicate with novices. These are possible future research topics.

The final cognitive science topic is problem solving.

2.5.3 Problem Solving

One area of research findings associated with questioning and design is problem solving. Much problem solving research has been done in conjunction with artificial intelligence research. Herbert Simon points out that artificial intelligence research has both borrowed from and contributed to research on human problem solving (Simon & Associates, 1986). Research on questioning associated with problem solving has contributed to the development of artificial intelligence, often focused on logical or linguistic aspects of composing, asking, and answering questions, and on effective means of organizing and retrieving data from large databases as a basis for development of computer programs that can emulate human conversations (Graesser, 1985). Research on question-asking in cognitive science sometimes works in two directions – obtaining data from humans to understand questioning, and also working backwards from successful artificial intelligence programs to try and better understand human cognitive processes (Singer, 1985). This should not be too surprising, as we do not understand exactly how human cognition works. No single method of research will provide all of the answers, but rather can be expected to contribute additional perspectives and details that will help us to increase understanding of human cognition.

Simon also discusses the need to better understand the early steps of problem solving processes. These are the steps that are least understood, such as how problems can be identified and represented in ways that facilitate solution. The way in which problems are represented is tied to the quality of the solutions found (Simon & Associates, 1986). This study investigating the earliest steps of instructional design situations, involves the initial steps of participant’s problem solving experiences.

Instructional design involves ill-structured problems with a large number of variables (Eseryel, 2006; Rowland, 1992; Wallington, 1981). Instructional design problems tend to have a wide range of solutions to address the large number of variables involved. Solutions can potentially be represented in multiple ways, with the number dependent on the designer’s goals and experience. Consider the problem of how to present a class lesson on penguins. Solutions could include any combination of lecture, video, Internet searches, images, or a field trip to the zoo. Any solution could be represented in many ways. If the presentation method of images is selected, possibilities for representation of penguins may include photos, paintings, sculptures, line drawings of penguins, or animated 3D penguins.

The way an instructor represents problems and solutions through use of rules, concepts, analogies, etc. is tied closely to effective presentation of that information and the student's own interpretation of the ideas being taught (student's attempts to represent). Effectiveness of instruction can be determined by assessing student learning (student's representing), and comparing results of the assessment with the expectations of the instructor, student, and/or organization. Optimally, the instructor, student, and organization would all be satisfied with the results of the assessment and no revision of the information or presentation would be required (high effectiveness).

While it may not be feasible to investigate the eventual effectiveness of questions asked during conceptual instructional design or the end results of instructional design efforts investigated in this study, instructional design cannot be considered successful until actual student learning has been assessed and found to meet user needs. Instead, this study focuses on identifying faculty's needs during early conceptual instructional design, with the goal of recommending means to better support faculty during instructional design. Improved support of faculty during instructional design may help faculty to devote more time and effort to developing effective question-asking strategies and creating and evaluating more effective instructional products.

2.6 Design Science

This section discusses field definitions, key research findings, and user issues with respect to design science. Design science incorporates design studies and design research, and includes the study-specific issues of questioning behavior and design, and user issues and design. Many of the current issues in design research are reflected in the results of this study (refer to Chapter 5). The final portion of this section discusses the nuclear power perspective on design science with respect to design as a discipline.

2.6.1 What is Design Science?

Design science is an umbrella term for both design studies and design research as part of an agenda to move all design fields toward a science of design. Over the past several decades the distinction between design studies and design research has become increasingly blurred. The terms are sometimes used interchangeably. The field of design studies has its roots in cognitive science and the work of Simon and Newell, predating the field of design research, while the roots of design research are in early efforts to better understand engineering methods. Today, issues, agendas and researchers tend to overlap between the fields. The following definitions provide a general academic definition of each field as used in this study. There does not appear to be a generally agreed upon formal definition of either.

Design Studies: A broad research program/agenda covering various aspects of design including: spatial, risk, urban planning, environmental, architecture and art in public domain, history and philosophy of design, real estate and finance for urban planning, landscape and plantscape design and ecology, and technology (Harvard University

Graduate School of Design, 2013). Design studies investigates the understanding of design processes from comparisons across all domains of application, including engineering and product design, architectural and urban design, computer artifacts and systems design (Elsevier, 2014).

Design Research: Research focused on understanding and augmenting engineering design and innovation practice and education, emphasizing human aspects as a central issue of design through interdisciplinary, integrative studies of social sciences and design disciplines. Design research investigates issues such as expertise in design, design learning strategies and design pedagogy, design as a social process, design methods and processes, gaming and simulation in design, designing user interfaces, the role of visual techniques in the design process, design tools, and sustainability (Inderscience Enterprises Ltd., 2014; Stanford Mechanical Engineering Center for Design Research, 2014).

Design studies and design research have become more critical as the global economy necessitates finding better, faster ways to design and teach design. Ironically, this has both improved recognition of the need for a discipline of design and created a new research dilemma. Design vocabulary and cultures can be so different across disciplines and organizations that ethnographic research has been suggested as a starting point for cross-disciplinary collaboration (Tully, 2013). This dilemma can be encountered in any design discipline.

The following sections discuss pertinent topics for Design Studies Research (section 2.6.2) and Design Research (section 2.6.3).

2.6.2 Design Studies Research

Design studies investigates the activities and cognitive processes of designers including expertise in design, design fixation, design education, design representation, and creative design (Buchanan, 2001; Oxman, 1996). All of these issues are reflected in the results of this study (refer to Chapter 5).

Design studies research tends to be strongly observation-based. Much of the research on representing within the field of design studies has focused largely on how engineers use external representations such as sketches to communicate with others and develop ideas (Goel, 1995) or on external representations of the engineering or architectural design processes (Eastman, 1999). Some researchers have investigated the cognitive processes of engineering designers. Ozgur Eris (2003, 2004) investigated question taxonomies, and Sridhar Condoor (1992, 2007) modeled cognitive design processes using a concept space/configuration space model, and is investigating design fixation.

Design studies research has established that designing is not ‘normal’ problem solving. Design studies investigates a range of issues not included in most prior problem solving research, such as: finding appropriate problems (not just solving them), problem structuring and formulating of complex and ill-defined problems, and convergent and divergent problem solving approaches (Ball, Ormerod, & Morley, 2004; Cross, 1999; Eris, 2004). This is an appropriate perspective on problem solving for instructional design, since instructional design also tends to focus on complex, ill-defined problems, finding and formulation of problems, and generation of both convergent and divergent potential solutions.

More recently, design studies research has taken a more holistic view of human information processing, focusing increasingly on "how" over "what" and addressing contextual and social issues (Eastman, 2001). Multiple studies have shown that improved reliability in design is likely only when our analytical, numerical, and computational design tools are supplemented with improved design thinking skills (Altshuller, 1996). Practical experience in the nuclear power industry supports the idea that improved questioning skills can help with design thinking.

Design studies research on expertise has shown: experts do not think like novices, may have difficulty explaining and justifying information from the standpoint of a novice, tend to operate at a higher level of complexity than novices, and may experience design fixation due to extensive domain knowledge (Ball, et al., 2004; Jansson & Smith, 1991; Ormerod & Ridgway, 1999; Purcell & Gero, 1996). This reflects expertise research in other fields.

2.6.3 Design Research

Design research initially focused largely on methods and has grown tremendously in the past 15 years. The current direction of the field is toward encompassing research on all aspects of design across all disciplines (Design Research Society, 2013). Design research is a huge field, encompassing all design disciplines, including engineering, architecture, art, education design, instructional design, graphics design, information design, packaging design, product design, software, business, management, and social design, web design, interaction design, service design, etc., applying many design processes and approaches, including axiomatic design.

The focus of design research is to develop a scientific approach to design, expand design cognition and education research, develop techniques to aid designers and support the concept of design as a discipline. For the purposes of this study, this section focuses primarily on the axiomatic design community and design as a discipline.

2.6.3.1 Axiomatic Design and the Discipline of Design

Axiomatic Design was developed by Nam P. Suh at MIT and was first published in entirety in 1990. Axiomatic Design has been shown to markedly improve designs while shortening the design time. The two axioms of axiomatic design are to maximize the independence of the functional elements and minimize the information, or complexity. Examples of functional requirements are chilling and freezing for a refrigerator, or learning outcomes for instruction. These are clear, simple rules that guide the design process to the best possible solution for the desired functions. Axiomatic design can be applied to the design of products, processes, projects, and systems for any design discipline (not just engineering). It has been called one of the most important engineering developments of the last hundred years (Suh, 1990, 2001, 2005, 2013).

A key concept associated with axiomatic design is the discipline of design: the idea that there are commonalities of design across all design disciplines. Engineering applications are still the most common use of axiomatic design, but it is spreading to other areas, and has the potential for real value within information fields. Axiomatic design is a scientific design theory, a design communication tool, and an organizational aid that supports design cognition – all very information-intensive, cross-disciplinary, and still very much evolving. A primary goal of the axiomatic design community is to further development of design as a science and gain acceptance for design as a discipline. These are also primary areas of dispute. Although axiomatic design can be applied throughout the design process, the current recommended approach per discussion at ICAD 2013 is to apply axiomatic design for conceptual design, and for as long as it is useful, and then use other methods (Rothwell, 2013).

Conversations at the ICAD/DCEE 2013 conference did not reveal any new research on cognitive question-asking, although it was mentioned that several design process models used in the corporate design thinking realm include general strategies for question-asking. Efforts to apply those models in design education have not been very successful (Rothwell, 2013).

Conversations and observations at the ICAD/DCEE 2013 conference reinforced the need for research on question-asking during design and the lack of effective means to teach designers and design students to ask better questions. This support was critical to move this study forward, as research and data in the commercial nuclear power industry on design as a discipline and the importance of questioning during design is not accessible.

2.6.4 Questioning Behavior and Design

Questioning is a critical aspect of designing behavior (Oliva & Hubbard, 2015), and is reflected in research on questioning in design research, cognitive science, psychology, and education.

In the U.S. nuclear power industry, it is mandatory to include user representatives in all engineering design teams from conceptual design until the plant modification is officially installed and tested in the plant. Users are involved in the design planning and review process, with responsibility for communicating pertinent aspects of the design to others in their work group and providing feedback to the design team. The safety of the plant and the public depends on getting engineering and instructional design right the first time. It is important to understand the user perspective and maintain a questioning attitude. The systematic design process (engineering and instruction/training) is heavily user-based, question-driven and question-oriented. (Oliva & Hubbard, 2015).

Unfortunately, much engineering and architectural design is not user-based, and does not focus on questioning. Review of Design Studies texts (Bucciarelli, 1994; Cross, 2011; Cross, Christiaans, & Dorst, 1996; Eris, 2004; Goldschmidt & Porter, 2004; Lawson, 2006; Margolin, 1989; Pahl, Beitz, Feldhusen, & Grote, 2007) showed strong focus on objects, environments, and systems, rarely mentioning users. A positive result of this review was that it located research on questioning behavior of engineering designers that (Eris, 2004) supports the design perspective of this study.

Eris investigated questions asked by graduate engineering students during a simulated design project. A question taxonomy was created from design session videos and was compared with several existing question taxonomies. Five new categories of questions were suggested for design: proposal/negotiation, scenario creation, ideation, method generation, and enablement, with a need for asking both convergent and divergent questions (Eris, 2003, 2004). This study is conceptually interesting, as it stresses the importance of researching questioning behavior in order to understand the basis for design decisions.

There is some similarity between the taxonomy that Eris developed and Roger Schank's taxonomy for questioning associated with creativity (Schank & Childers, 1988). Roger Schank classifies questions as reminding-based (you are reminded of them by something else), reason questions (why?), event questions (what caused ___?), and outcome questions (what will happen?). Schank then discusses transformation of questions as an aid to creativity. For example, taking a reason, event, or outcome question and using it as a starting point to generate a chain of questions to help you better understand something, or as a way to try and generate new ideas. He also discusses transforming questions as a means of turning creativity into practical applications. For example, transforming ideal questions into pragmatic questions, or transforming wish-fulfillment questions into planning questions. The idealistic question "Could I win the Olympic basketball gold medal?" could be transformed into question such as "How good are my basketball skills?" or "What would I need to do to try and become an Olympic basketball player?"

Schank's question transformations are often converging or diverging questions, similar to those Eris investigated. Ormerod et al. have also determined that creativity and questioning are part of successful instructional design and information seeking (Ormerod & Ridgway, 1999; Wilson & Walsh, 1996). This further supports the idea that design and creativity can be aided by learning to ask more diverging and converging questions.

2.6.5 User Issues and Design

There is a trend to address user issues within design studies, sometimes with the admittance that users are little understood by designers and that more user involvement in design is needed. An issue with any type of user research on design is the complexity of design cognition. User research in general has focused on shorter-term processes, such as web browsing, use of library reference services, and specific types of human-computer interaction (refer to section 2.2.3.1). These activities are more well-bounded, shorter-term, less iterative and less complex than design. Studying design cognition is time-consuming for both researcher and participants, and is often expensive and difficult. Design studies is still a relatively new field. A large amount of research is required to obtain a better understanding of design cognition.

Design science research has investigated a variety of students' engineering design tendencies, finding that iteration, use of a systematic approach to design, and instruction on a systematic approach to design can help students improve design quality (Cardella, et al., 2005). However, there does not appear to be any design science research on whether instruction on a systematic approach to questioning would be beneficial.

2.6.6 The Nuclear Power Perspective: Design as a Discipline

This section is provides an overview of several key concepts that have contributed to the development of design as a discipline in commercial nuclear power. This is in part background for the interdisciplinary ad-hoc design mapping analysis performed to map results of this study to the larger arena of design as a discipline (refer to Appendix O).

Design perspectives include: design prediction as a balance dilemma, risks of technological complexity and complacency; and the evolution of the philosophy of design as a discipline as practiced in nuclear power.

2.6.7 Design Prediction: The Balance Dilemma

An important aspect of complex design is the difficulty of balancing current needs with potential future consequences. It is easier to focus on current issues than it is to focus on and predict problems that may later emerge as side effects of our actions (Xiao, et al., 2011). A balance is needed, but it can be very difficult to reach that balance. Here are some reasons why (Oliva & Hubbard, 2015):

1. Design is limited by our understanding of nature, materials, systems, behaviors, and our education and training, which in turn are limited by the constraints of instructional design, instruction, and learning. We can improve design through instruction, but to improve instruction we need to better understand design.
2. We cannot always predict how technology will respond to all possible system interactions, environmental conditions, or technological and human failures, nor can we always predict how humans will interact with technology. People may use or react to technology in ways they themselves, designers, and instructors never thought of, sometimes with catastrophic results.
3. A systematic approach to design that reviews and questions issues from both user and technology-based perspectives can help designers cope with the increasing complexity of design (cognitively and in practice), identify a broad range of design criteria, prioritize appropriately, and achieve balance.

4. Too much focus on keeping users happy can create a designer bias toward satisfaction of immediate user needs. This can distract designers from technical and natural design limitations, safety, or instructional goals. Similarly, overemphasizing technology can distract designers from human issues.

The effort to attain this balance is another aspect of the magic of design, as the thought processes involved are likely to be invisible to the designer and others. An associated concern is the risks of technological complexity and complacency.

2.6.8 Risks of Technological Complexity and Complacency

Complexity is the existence of many interdependent variables in a given system (Dorner, 1996). Complacency is a state of satisfaction with the way things are. Where design involves risk, safety, or complex technology, the consequences of underestimating complexity and complacency can be severe. Dorner has stressed the risks of interdependency, a characteristic of complexity that requires users to attend to many features simultaneously, making it difficult or impossible to undertake only a single action with respect to a system. (1996).

In the past, human error rarely resulted in widespread disaster. Now, the nature and scale of some potentially dangerous technologies can result in human errors adversely affecting entire continents over several generations (Schneider, 2007). A higher level of caution is required, and as technology becomes increasingly ubiquitous, the need for caution is rapidly reaching down to the level of small businesses and homes (Vijaykumar & Chakrabarti, 2007). Robert Pool points out that modern technology is qualitatively different from earlier technologies due to the level of complexity. Earlier technology, such as the plow and light bulb are simple devices with form, function, and capabilities that can be readily understood in all of their flavors. He states that ”No individual can understand completely how, for example, a petrochemical plant works, and no team of experts can anticipate every possible outcome once a technology is put to work. Such complexity fundamentally changes our relationship with technology” (Kolko, 2011, p. 9).

A few examples of the results of technological complacency include the loss of the space shuttle *Challenger* (Vijaykumar & Chakrabarti, 2007), severe incidents at nuclear power plants (Fosmire, 2012), the ongoing use of damping devices on buildings in the eastern United States to compensate for wind effects that the structures cannot handle without assistance (Cross, 2007), grounding of the *Royal Majesty* cruise ship (Vijaykumar & Chakrabarti, 2007), and the Three Mile Island and Chernobyl nuclear power plant accidents (G. Medvedev, 1991; Walker, 2004).

Non-technological systems such as social and economic systems, governments, and organizations can also be seriously impacted by complacency about design (Oliva & Hubbard, 2015). An example is the poor handling of Ebola patients recently, in part due to a healthcare and social system which was not designed or maintained in a way that would discourage complacency (Agyepong, 2014). Technology can be the vehicle for design-related disaster if we are complacent about human behavior (Oliva & Hubbard, 2015). An example is cyber terrorism and the need to design systems that are resistant to the actions of cyber criminals (Hua & Bapna, 2013; Tehrani, Manap, & Taji, 2013).

Poor education and lack of information sharing can contribute to complacency (Altshuller, 1996). Much nuclear power industry education is based on minimizing the potential for complacency and helping personnel deal with complex technology (Oliva & Hubbard, 2015). Design studies research has pointed out the need for increased awareness of and education on complexity and complacency in engineering design (Saleh & Pendley, 2012). The extent to which technological complexity and complacency are considered within academic instructional design in areas other than engineering design is unknown.

Technological complexity and complacency are also associated with instructional technology itself. As an example, computer simulations are often used in nuclear power, aviation training, and the military. Henry Petroski has expressed concern that these simulations are subject to the same limitations of predictability and reliability as other technology. He also expresses concern about the use of computer models for testing, for example structural testing. Computer models often assume perfection and do not account for flawed materials or loose bolts (1996). James Chiles takes a positive perspective, discussing how "harsh training on a realistic simulator can teach failure so vivid and complete that it breaks through unjustified confidence" (2007).

These are valid points. Fidelity of simulation can be both an asset and a danger, depending on how accurate the simulation is and how well associated instruction or modeling fits cognitive and physical reality. Whether education/training is targeted toward use or design, instructional designers have a role to play: in design and use of the instructional technology, in training people on the technology itself, and on educating people about the inherent uncertainties and limitations of design and use. It is a fact that people make errors, and that we will never achieve perfection, especially in complex systems (Oliva & Hubbard, 2015). Researchers at the ICAD 2013 conference stressed the need for improved design support to help designers cope with the ever-increasing complexity and information overload associated with design in a global economy (Rothwell, 2013).

Instructional design and instruction are ongoing needs in complex technological environments (Oliva & Hubbard, 2015). James Chiles emphasizes that manual skills often stay with us for life, such as the classic example of riding a bicycle, but the high-level cognitive skills required to work with complex technological systems need frequent refreshing and updating (2007). It is critical for instructional designers and instructors to keep up with change, which is where a systematic approach can be very beneficial. Careful tracking of skills, performance, lessons learned, and individual training is necessary to develop and maintain competent personnel. Note that a systematic approach does not mean a rigid, prohibitive approach. It is a flexible approach that takes into account multiple options and tracks ideas, actions, results, and *questions* in ways that assist us to identify problems and successes, and learn from experience. Questioning behavior can play a critical role, especially where rapid change is involved – for designers, instructors, and learners. We need to ensure that our students are aware of the important role of questioning when working with complex technology or systems (Oliva & Hubbard, 2015).

The next section outlines the evolution of the philosophy of design as a discipline.

2.6.9 From Discipline of Technology to Design as a Discipline

The U.S. nuclear navy submarine program was the birthplace of a unique heritage; "the discipline of technology," a holistic approach to dealing with complex technology that is the legacy of Admiral Hymen G. Rickover. This philosophy was initially developed by Rickover during the early days of the nuclear navy submarine program in the 1940s. It was proven in commercial nuclear power by the Shippingport Atomic Power Station, the first large-scale nuclear power plant in the world operated only to produce electric power and advance reactor technology for civilian application. The philosophy was institutionalized by the Institute of Nuclear Power Operations to build community and communitarian regulation following the Three Mile Island nuclear power plant accident in 1979 (M. Aurisicchio & Bracewell, 2013). Rickover's philosophy has since been adopted in part by the international nuclear community and some other high reliability organizations such as air traffic control (Weick, Sutcliffe, & Obstfeld, 1999), but is still not widely known (Oliva & Hubbard, 2015). A combination of factors makes "the discipline of technology" unique:

- A proven record of success for over sixty years (M. Aurisicchio & Bracewell, 2013; Crawford, 1998; Fosmire, 2012; Hargrove-Leak, 2012; Hasso Plattner Institute, 2013; Kolko, 2011, 2012; Mabogunje, 1997; Rhodes, 1993; Vijaykumar & Chakrabarti, 2007).
- A holistic, cultural philosophy applicable for all individuals, groups, and tasks at all levels of an organization, including design, stressing technical training,

competence, excellence, safety, questioning, attention to detail, learning from experience, and technical and moral responsibility (Oliva & Hubbard, 2015).

- An overriding focus on minimizing the possibility of disaster and requiring "thorough and deep consideration of the match between the product and its use, and intense analysis of the present and anticipated future conditions of operation" (M. Aurisicchio & Bracewell, 2013). This was an attitude well ahead of its time.
- Principles that " acknowledge the complex technology" (Rickover, 1983) and the "strength of the forces of nature harnessed by a technology" (Kolko, 2012).

The discipline of technology and the principles of defense in depth and diversity are in part supported through the application of systematic, iterative, user-based approaches to design. Rickover's discipline of technology is essentially what is now termed `design as a discipline.'

Stress on the role of education and training to help people design and work with complex technology in more effective and safer ways is a hallmark of Rickover's discipline of technology, and is an accepted component of high reliability approaches (Oliva & Hubbard, 2015). A systematic approach to training/education has been identified at the international level as being particularly important to maintaining a strong safety culture and avoiding technological complacency (Kuhlthau, et al., 2012). This idea comes directly from Rickover's discipline of technology (M. Aurisicchio & Bracewell, 2013), considers instructional design as design in a similar sense as engineering design, and has been widely adopted in the commercial nuclear power industry. A systematic approach to design includes tracking problems, questions, options, unknowns, possible solutions, lessons learned, industry events, etc. (Oliva & Hubbard, 2015).

The concept of a systematic approach to training/education is not unique. It has a long history in instructional design. However, the concept of addressing instructional design in the same way as engineering design may be unique to nuclear power (Oliva & Hubbard, 2015). The closest similar instructional design approach identified during review of the instructional design literature is that of Alex Romiszowski's *Designing Instructional Systems.* He takes a highly systematic, large-scale, detailed, yet open-minded and flexible contextual approach to instructional design, with a high level of analysis prior to making critical decisions. Theory is supported with practical experience, and problem identification and problem solving are both emphasized (1981). In nuclear power, both engineering and instructional design apply a large-scale, extremely systematic yet flexible approach to design (Oliva & Hubbard, 2015).

Design researchers, educators, and practitioners are beginning to shift toward acceptance of the concept of design as a discipline, particularly within the axiomatic design community, but are still far behind the U.S. commercial nuclear power industry with respect to developing a comprehensive and systematic approach to design. That requires not only research and practice, but a cultural change (Oliva & Hubbard, 2015). The design mapping performed as part of this study provides a starting point for future testing of specific design support concepts from nuclear power in other design contexts.

Finally, we see how questioning behavior links the concepts in this literature review.

2.7 Questioning as the Missing Link

Literature review makes it clear that there is no single solution to improving design. James Chiles (2007) has even suggested that the long-term solution to reliably dealing with complex technology and high risk is human evolution from *homo sapiens* to "*homo machina*, 'machine man,' a species able to understand what it really takes to build and run complex, high-power systems in a world with forces that are still a lot more powerful than we are." He traces an early appearance of the new species to Admiral Hymen G. Rickover (Vijaykumar & Chakrabarti, 2007). There is good reason for this. The U.S. nuclear navy submarine program and commercial nuclear power share a unique heritage; "the discipline of technology," a holistic approach to dealing with complex technology that is the legacy of Admiral Hymen G. Rickover (M. Aurisicchio & Bracewell, 2013). This philosophy was developed by Rickover early in the nuclear navy submarine program and included the roots of a *questioning attitude* and a systematic approach to training and design. Philosophies and techniques used today in nuclear power to reliably perform design and training, share information, deal with complex technology and uncertainty, and involve users in design are all based upon Rickover's discipline of technology. Questioning during design is a critically important factor (Oliva & Hubbard, 2015). Per Oliva: "Rickover's philosophy has been embraced completely by the Institute for Nuclear Power Operations and has grown over the years as we continue to check and adjust our industry via operating experience" (2015).

Questions can be viewed as the missing link that ties together the concepts discussed in this chapter. Questions asked by experts are likely to differ from questions asked by novices, but are a necessary design tool for both. Asking and thinking about questions is an important part of learning, helping us tie new ideas to past experience and explore new possibilities. Questions create links, paths to possibilities, and bridging of information gaps (see Figure 5). Questions can be creative tools, and are believed to help reduce cognitive load and assist with recall, especially when working under pressure in a short time frame when human error may be more likely (Oliva & Hubbard, 2015). Skilled questioning during instructional design is critical to identify design perspectives and constraints. Designers-by-assignment can be aided by tools that help them think effectively and ask questions without prescribing specific instructional design models or procedures (Oliva & Hubbard, 2015), a direction for future research.

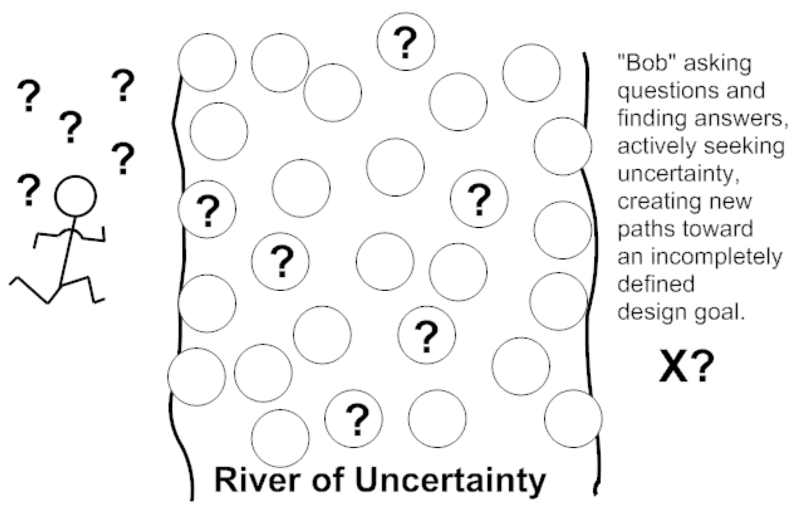


Figure 5. Designing Behavior: Crossing the River of Uncertainty

Questions are important for all phases of designing, helping us to seek information, identify and explore options and problems, make decisions, solve problems, and evaluate our thoughts and actions (Oliva & Hubbard, 2015). This study will contribute to a better understanding of question-asking behavior during design by illuminating information gaps that exist for instructional designers early in the design process, exploring question context from the user perspective (faculty performing instructional design), and provide insight into question-asking practices, values, and means of coping with uncertainty. Investigating questioning behavior as part of a systematic approach to design can help us understand how to help designers and design students.

2.8 Literature Review Summary

Although there are related research threads in user behavior, cognitive science, design studies, instructional design and motivation, no research has been found that unites these research areas with respect to questioning during design. Contributions of the literature review to the research conceptualization of this study are shown in Figure 6.

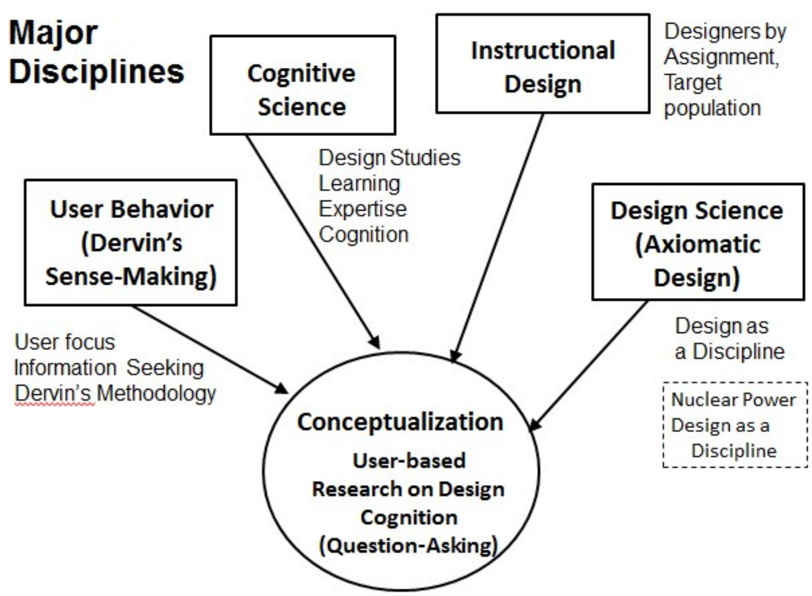


Figure 6. Research Conceptualization Diagram

Literature review provided justification for the conceptual background of the study, validated the need for research on question-asking during design, and contributed to development of the study design, discussed in Chapter 3.

CHAPTER 3. METHODOLOGY

"There were times where I had this mental picture that I have taken off from a small grassy field in a biplane and I'm going to be renovating the plane while I'm flying and basically turning it into a jet aircraft before I land."

- A participant describing the designing experience

3.1 Introduction

This chapter covers the methodological approach to the study, discussing Dervin's Sense-Making Approach including operationalization, units of analysis, and alternative methods and approaches. Research design is discussed including population and sampling, recruitment, participant demographics, establishing data saturation, means of establishing reliability and validity, research procedures, data collection, intercoder reliability, and data analysis.

3.2 Methodological Approach

The purpose of the research was to investigate information seeking and question-asking behavior during conceptual instructional design among faculty who have been engaged in instructional design involving a topic or method that was new to them or cross-disciplinary. This was a qualitative descriptive research study applying Brenda Dervin's user-based sense-making methodology to guide participants through discussion of questions asked and cognitive aspects of asking and resolving those questions. Data analysis looked for patterns of information gaps, information seeking strategies, complexities, and needs. This study is a step toward improving design and design education support, and toward future research on interventions to support question-asking during design.

3.2.1 Dervin's Sense-Making Approach

Brenda Dervin's Sense-Making Approach provides a user-based perspective for cognitive information-seeking behaviors (B. Dervin, 1983; B. Dervin, et al., 2003b). Refer to Chapter 2 for the associated user-based conceptual framework. This section discusses methodological application of Dervin's Sense-Making Approach including operationalization, units of analysis, and strengths and limitations of the methodology.

3.2.1.1 Operationalization

Operationalized definitions were presented in detail in Chapter 2 so the reader would better understand Brenda Dervin's conceptual approach and are summarized here:

Gaps – are conceptually defined as anything the respondent wanted to find out about, was confused about, or was just curious about, representing persistent uncertainty as perceived by the user and indicating cognitive gaps the user faces. Gaps are typically operationalized as questions/concerns (B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986).

Resources – are conceptually defined as information, data, computing functionalities, or links (Nilan, 1992). Resources are operationalized as sources of questions (who, what, or where a user finds an answer to a question).

Participant – participants are higher education faculty who have had a recent instructional design experience (within approximately the last six months or ongoing).

*Situation or Problem – t*he situation was a specific recent or significant situation when the respondent needed to design an instructional experience or instructional materials for any of the following:

- A cross-disciplinary course or lesson
- A topic the user was not very familiar with
- To create a type or means of instruction the user had not tried previously

Sources – are conceptualized as who, what, or where a user found an answer to a question.

Steps – are conceptually defined as the cognitive behavior of the respondent or others, or events that occurred during the respondents' specific life experience. Steps are operationalized as something you did, something someone else did, or something that just happened (B. Dervin, 1983; B. Dervin, et al., 2003b; Nilan & Mundkur, 2007).

Uses – are conceptualized as the ways that people put answers to their questions to work (B. Dervin & Nilan, 1986). Uses are operationalized as helps (positive) or hurts (negative).

3.2.1.2 Units of Analysis

Units of analysis for Sense-Making are based on Dervin's cognitive movement metaphor rather than on the characteristics of the user. Problems, steps, gaps, or uses rather than the users, are typical units of analysis (B. Dervin & Nilan, 1986).

Understanding the problems that users perceive is necessary to make sense of the steps a user takes and the questions a user asks when gaps are encountered. This provides a basis to investigate information seeking and problem solving. The instructional design context can incorporate an extensive range of potential problems/difficulties and goals, beyond what expected dissertation research could effectively model. This is typical for design. Design typically involves more considerations of context, design requirements, unknowns, risks, user needs, etc., than can be effectively investigated in the expected dissertation timeframe. Therefore this dissertation research study focused only on the early conceptual stage of instructional design.

Questions are major factors in the path to a final design (Oliva & Hubbard, 2015). Questions help identify and address problems/difficulties that need to be resolved as users move through their life experience (steps) toward their design goals. Looking at the full question context of problems, steps, resources, uses, and helps/hurts is necessary to interpret the implications of individual questions (B. Dervin, 1983; B. Dervin & Dewdney, 1986; B. Dervin, et al., 2003b). Therefore, gaps (persistent uncertainty as perceived by the user) were selected as the primary unit of analysis for the study, operationalized as questions or concerns.

3.2.2 Information Needed and Alternative Methods and Approaches

This section reviews the information needed to address the research objectives and then summarizes the basis for selection of Dervin's Sense-Making Approach over alternatives.

3.2.2.1 Information Needed to Address the Research Objectives

Review of the research objectives and previous pre-testing and pilot testing established what information and evidence is needed to address the research objectives. This section discusses the information required to address the research objectives and to support the overarching goal of the study.

General RO: To empirically describe faculty's articulations of their cognitive question-asking behavior during early conceptual instructional design. Refer to RO1 through RO4 for required information to address this General RO.

RO1: To explore questions faculty ask during early conceptual instructional design.

Required information for RO1: Details of participants questions/concerns and question context were needed to empirically describe faculty's articulations of their cognitive question-asking behavior during early conceptual instructional design. This was necessary as a starting point for improvement of design support and to support future research.

RO2: To identify uses that faculty associate with the questions they ask during their conceptual instructional design experience (Example: Did it help or hurt?).

Required information for RO2: Identification of uses faculty associate with their questions required obtaining detailed information on question context, including why questions were asked and why participants had concerns or needs. 'Why' is important for understanding complex situations requiring critical decision making. Uses provide insight on problems.

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

Required information for RO3: Identification of patterns of behavior required having adequate detail about the cognitive question-asking behavior of participants to be able to compare what people did, thought, asked about, struggled with, succeeded at, etc., across all participants. Designing is a complex behavior. More than one or two elements of behavior are required to describe designing behavior adequately to determine specific means of design support.

Data from Sections One, Two, and Three of the interview protocol (Steps, Questions, Question Context) was necessary as a basis for deductive and semi-inductive content analysis to identify patterns of behavior. General patterns of behavior were also identified through analysis of big picture data collected in Section Five of the interview protocol, such as learning. However, big picture data is based on very broad questions with little or no additional context, and may be less reliable.

RO4: To explore what faculty feel is important about question-asking during instructional design. For example: How does it make a difference in the quality of instruction as compared to when they overlook or leave out questioning? What are the most important things faculty want to share about question-asking, such as critical issues, something they are confused about, or a question they wish they had asked?

Required information for RO4: Big picture data illustrating what faculty feel is important about question-asking during instructional design is an additional contextual and personal component of participants' instructional design experience. The open-ended big picture questions in Section Five of the interview protocol were required to obtain information that was used to address RO4.

Overarching Goal: To provide a basis for future research on interventions to aid designers from all disciplines with question-asking during design.

Required information to support the Overarching Goal: Question and question context data are required as a comparison platform for questions asked in other design disciplines. An ad-hoc design mapping analysis was used to explore transferability of questions asked by participants to other design domains. Refer to section 3.7 and Appendix O for details.

3.2.2.2 Dervin's Approach versus Alternative Methods and Approaches

There were a lot of unknowns involved in the issues investigated in this study. That ruled out most traditional closed-ended such as surveys that target specific variables and criteria, and may be associated with certain elements of behavior. Experimental approaches wouldn't fit for similar reasons – there are far too many variables to formulate realistic hypothesis.

Dervin's Sense-Making approach fit most of the requirements to address the ROs. Dervin's approach was designed to provide data on users' cognitive activities. It is a proven framework for user-based research that focuses on identifying questions, concerns, uses, and patterns of user behavior.

However, there are some limitations. Dervin's approach apparently has not been used to investigate a small part of a larger behavior (i.e. early conceptual instructional design), and has not investigated a complex iterative behavior such as designing. Live interviews about complex design situations can be very time-consuming, limiting the research scope. A case study could result in more detailed elicitation of data across a longer period, resulting in more data on users' actual questions. But a case study in a dissertation research timeframe would have to include very few participants, and might not provide an adequate variety of data. Critical Incident Technique is a good means of eliciting depth on cognitive behaviors in a short timeframe, but the increased focus on key events could result in loss of necessary details of designing behavior.

Use of timeline interviews for complex behavior could also have unanticipated complications. Participants sometimes have difficulty expressing design experiences in terms of the interview questions. Document analysis could provide a variety of data without requiring face-to-face interviews, but would be extremely time consuming, data access could be problematic, and it's likely that context would be too narrow.

Overall, Dervin's approach appeared to be the best fit for investigating question-asking behavior during early conceptual design. It can effectively elicit the required data.

3.3 Research Design

This section discusses research design, including population and sampling, means of establishing reliability and validity, and Sense-Making research procedures.

3.3.1 Population and Sampling

This section discusses the study population, sampling plan, data saturation, sample size, sampling methodology, and sampling implementation.

3.3.1.1 Population

The population of interest is higher education faculty who had a specific recent or significant situation (within approximately the last six months or ongoing) when they needed to design an instructional experience or instructional materials for any of the following:

- A cross-disciplinary course or lesson
- A topic they were not very familiar with
- To create a type or means of instruction they had not tried previously, such as online instruction, flipped classroom, or video demonstrations.

This ensured that faculty had an instructional design experience in which they were likely to have a range of questions. Faculty working in areas they are intimately familiar with, using methods they are also very familiar with, are not likely to have as many questions. Research within a higher education environment provided a broad range of instructional design behavior to investigate.

3.3.1.2 Sampling Plan

The sample was planned to collect a wide range of questions across a range of instructional design experiences in higher education. The researcher's experience with instructional design in industry and academia has been that instructional design experience, discipline/type of course/subject matter, and subject matter expertise are primary factors affecting questions. Age (largely as associated with experience), type of institution, regulations and requirements, and organizational and social/cultural factors (expectations, attitude toward asking questions, freedom to make changes, etc.) may also play a role.

Sampling was planned to extend across several sizes and types of institutions: two year and four year, large, medium and small, public and private, likely to have variation in academic disciplines and requirements. Sampling was planned across several schools or departments and multiple academic disciplines at each participating institution (a range of subject matter and types of courses), and across a range of faculty within each school or department (graduate student instructors, adjunct faculty, and junior and senior faculty). Participants were all from institutions of higher education in central/western New York State and central Pennsylvania. This provided a wide range of instructional design and subject matter expertise and age, as reasonable within sampling and recruitment requirements of participating institutions.

Ethnicity was not expected to be a factor in question-asking behavior, other than possibly indirectly as related to cultural issues, but multiple ethnicities were included to show that a range of faculty participated in the study.

3.3.1.3 Achieving Data Saturation

Questions were the unit of analysis for this qualitative study with the goal of deep descriptions of question-asking behavior. Enough participants were required to generate adequate questions for data saturation.

Saturation needs to be determined on a study-specific basis, and generally requires some estimate of the point at which saturation will occur (Guest, Bunce, & Johnson, 2006; Sandelowski, 1995). Saturation for this study was defined as the point in the study when no new substantive types (kinds) of questions were still being found, within reasonable constraints based on the general instructional design environment, data collection time frame, and nature of the research. It was not possible or expected to reach 100% data saturation in a small and somewhat exploratory descriptive study.

As an example of how the general instructional design environment can constrain the range of questions gathered, in some higher education institutions it is possible that questions could be collected on building safety culture in nuclear power or effective means of improving the performance of water polo players. These questions could bring up specific concerns about risks of inadequate simulation fidelity and the need for specialized strength training that would not be encountered in other more common academic subject matter areas, or at all institutions. However, these types of questions are less frequently encountered and do not indicate big, new, frequently and obviously recurring patterns of designing behavior that would typically be expected in the mainstream academic environment. While some infrequently encountered questions are likely to be identified in the study, they are not a primary focus. Infrequently encountered questions would be good candidates for future research.

Experience in nuclear power has shown that sometimes infrequently asked questions can be some of the most important questions (Hubbard, 2015a).

Similarly, data collection performed in the summertime when many faculty are unavailable limited both range of faculty and range of academic disciplines that could reasonably be included in this study. However, including a wide range of faculty across a wide range of academic disciplines permitted reaching data saturation.

3.3.1.4 Sample Size

In previous sense-making research I've done, some level of redundancy, consistency, mega categories, and patterns in participants' situations, questions/concerns, and actions began to appear at five or six interviews. Patterns became generally apparent within approximately 10 to 12 interviews. Pilot testing collected an average of approximately six questions per participant. Some of that previous research involved less complex and more linear behaviors than instructional design, such as online purchasing. Simpler behaviors appear be likely to generate fewer questions than complex behaviors, and patterns of behavior appear to be more difficult to identify for complex behaviors. It is reasonable to expect to see regularities in data by the 10th interview as a minimum starting point for evaluation of data saturation, provided that at least two educational institutions, a range of academic disciplines, and a mix of participant instructional design expertise were considered. Recruitment was continued until data saturation was reached.

3.3.1.5 Sampling Methodology

Purposive sampling was selected for the study because the focus was on eliciting and describing a wide range of opinions and ideas across a diverse range of participants, rather than on proportional representation. Purposive sampling is often recommended for qualitative, interview-based research, as it is a strategic means of establishing a good correspondence between the research questions and the sample (Bryman, 2004). Per David Krathwohl, purposive sampling is appropriate when sampling choices are made with the intent of developing understanding and explanation and helping people learn about the phenomenon (Krathwohl, 1998; Patton, 1990). Purposive sampling is also appropriate and very useful for research involving description of a phenomenon about which little is known (Kumar, 2005). Neuman adds that purposive sampling is useful to select especially informative cases, select members of a difficult-to-reach specialized population, and identify specific types of cases for in-depth investigation, more to gain a deeper understanding than to generalize to a larger population (2000). That was the situation for this study.

Clear criteria are important to describe and defend purposive samples. The primary weakness in purposive sampling is the potential for inaccurate criteria and resulting poor sample selections (Gay & Airasian, 2000). The criteria for purposive sampling for this study were clearly stated in terms of specific instructional design situations, range of faculty, academic disciplines, and educational institutions expected.

Random selection from faculty rosters was considered, but was rejected due to the very large number of faculty that would probably need to be contacted to identify potential respondents. None of the potentially participating institutions have a means of identifying faculty who are designers-by-assignment.

3.3.1.6 IRB Approvals

This study was approved by the Syracuse University IRB. Appropriate IRB approvals, letters of cooperation (if required), and department chair approvals (if required) were obtained for all participating institutions prior to beginning recruitment activities.

3.3.1.7 Sampling Implementation

Sampling of faculty was performed across three upstate New York universities and colleges and two colleges in Pennsylvania. This sample had advantages in that it represented a range of institutions from small to large and included both two and four year institutions and a wide range of subject matter. A limitation of this sample was that it is restricted to a fairly small geographical area, with the majority of the institutions having a known interest in faculty development as exhibited through their participation in the Finger Lakes Faculty Development Network. Several participating institutions ensured better coverage of the geographic area, increasing validity of the results. Future research would be expected to involve a more extensive sample of institutions and participants to improve the generalizability of the results.

Sampling approaches were determined during preparation of Institutional Review Board (IRB) applications, and varied within parameters established by the Syracuse University IRB. One institution required recruitment to be based on publicly available information from the school website, restricting recruitment to several individuals per department contacted by email with the approved recruitment letter attached. The process at three other institutions was similar, but also required department head approval by email prior to contacting several previously targeted faculty in that department. One institution permitted recruitment of two rounds of five to six faculty. Several targeted faculty suggested other faculty as potential participants. Faculty were contacted across a range of academic disciplines to ensure diversity.

3.3.1.8 Recruitment

Recruitment was primarily performed by a combination of accessing the publicly available institutional web site, locating summer course schedules and faculty listings, and reviewing faculty information and summer schedules to select potential candidates for recruitment. All recruitment was based on the sampling plan for the study within the constraints imposed by the Syracuse University IRB, the IRBs of participating institutions, and requirements of individual schools or departments. Generally several departments were targeted at each institution, with from one to several faculty contacted per department. Care was taken to contact faculty across a wide range of academic disciplines. Graduate student instructors, adjunct faculty, and junior and senior faculty were contacted. As summer teaching schedules were not always publicly available or accurate, and faculty may not check email regularly during summer, it is unknown how many of the targeted faculty were actually available on campus during the summer. Graduate students often were not listed on summer schedules or departmental faculty listings, did not have contact information listed, or had outdated contact information. Best efforts were made to identify faculty who were likely to be available, but in several cases it was later discovered that targeted faculty were no longer employed at the institution. After obtaining any required departmental approvals, potential participants were contacted by email.

Personalized emails were distributed with a copy of the approved recruitment letter attached. Refer to Appendix F for a copy of the recruitment letter.

Most faculty who responded to the recruitment letter were able to schedule and complete data collection interviews. Two were unable to interview because they had to relocate on short notice, and two were at remote locations and requested a phone or online interview – an option not available for this study. As Dervin's approach works best face-to-face for timeline interviews, all interviews were performed in person on campus in an office or other reasonably private location such as a conference room. Remote interviews will be considered for future research. Recruitment results are shown in Table 3. A wide range of academic disciplines were covered for the final sample size, with 17 disciplines across 18 participants.

Table 3. Recruitment Results

Institution	Total Attempted Contacts	Participants
1	24	8
2	32	8
3	6	1*
4	6	1
5	6	0**
Total	80	18

Subject Areas
Clinical Serology, Engineering Design, Advanced Ceramics, Game Design and HCI, Culinary Arts, Architecture, Workforce Development, Preparation for Teaching, Civil Engineering Materials, Chemical Engineering, Art, Introduction to Old Testament, Principles of Learning, English, Automation Control, Multimedia, Microsoft Excel

*One additional participant volunteered and was interviewed. That participant was involved in an IRB review for the study, resulting in data that was less valid than other study data. This data was used only for coding and design mapping practice and pilot testing.

** Visitation date conflicted with pre-fall-semester faculty events. Faculty were not available for interviews.

3.4 Participant Demographics

Demographic data was collected to show that a range of participants were interviewed. A range of participants is important to minimize bias. Frequency counts were used to analyze basic descriptive demographic data consisting of age range, ethnic background, experience level, years as instructional designer, and gender in order to provide insight on the range of participants.

Due to the small size of the sample, to maintain confidentiality no data on the associated educational institutions is provided other than stating that data was collected from higher education faculty (full time, part time, adjunct, and graduate student instructors) at three colleges in upstate New York and one college in central Pennsylvania. Small, medium and large institutions were included with two to five year degree programs across a wide range of academic disciplines. Participant ages are reported in terms of age ranges in order to maintain confidentiality. Table 4 shows the frequency counts for demographic data including age, ethnicity, and gender.

Participant age ranged from 30 to over 60 years old. Although several faculty below 30 years of age responded to recruitment efforts, none were available locally for interviews. The average age of participants was 48 years. 75% of participants were in the age ranges of 30 to 39 or 50 to 59 years. The remaining 25% were evenly divided between 40 to 49 years and over 60 years of age. Age was self-reported.

Table 4. Demographic Data for Age, Ethnicity, and Gender

Category	Subcategory	Frequency	Percent of Total
Age in Years	20 to 29	0	0.0%
	30 to 39	6	37.5%
	40 to 49	3	12.5%
	50 to 59	6	37.5%
	60 and Up	3	12.5%
	Totals	16	100.0%
Ethnicity	White or Caucasian	14	75.0%
	Mixed	2	12.5%
	Indian, Asian, or Asian American	2	12.5%
	Totals	16	100.0%
Gender	Female	8	43.8%
	Male	10	56.3%
	Totals	18	100.0%

Participant ethnicity was also self-reported. The majority of participants were White or Caucasian (75%), with the remaining participants evenly divided between Indian, Asian, or Asian American and Mixed. Participant gender was more balanced than either age or ethnicity, with 43.8% female and 56.3% male.

Self-reported data on participant expertise and years of experience was also collected, and is displayed in Figure 7. Experience data was collected using a Likert scale, where 1 was little or no experience and 10 was an expert. Participants were also asked how many years they had been designing instruction.

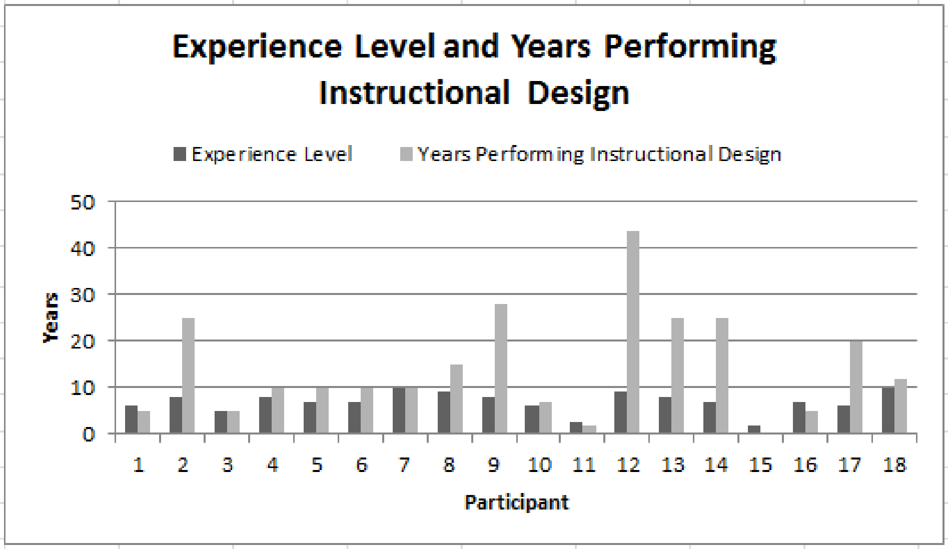


Figure 7. Experience Level and Years Performing Instructional Design

Data on experience level for and years performing instructional design are illustrated in the bar chart for comparison. A substantial range of years performing instructional design is exhibited, with a maximum of 44 years and a minimum of zero years (participant was in the middle of her very first instructional design experience). The majority of participants (11) had from 0 to 10 years of experience (61%), with the most commonly reported amount of experience being 10 years (22%). Five participants (27.7%) had 25 or more years of experience. The average amount of experience with instructional design was 14.3 years. Experience level data leans toward expertise, as shown in Figure 8, with eight participants scoring themselves at an 8, 9, or 10 (44.4%). Eight participants scored themselves at 5, 6, or 7 (44.4%). Only two participants ranked themselves below a 5 (11.1%).

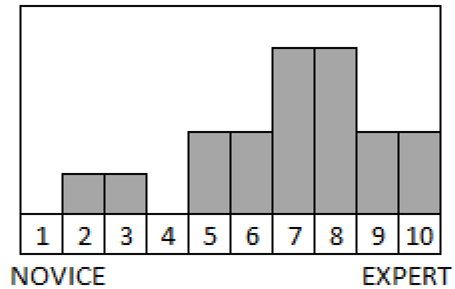


Figure 8. Likert Chart for Expertise Self-Ratings

3.4.1 Discussion: Range of Participants

The range of participants was not as wide as hoped for, with fewer novices than experts and no participants below age 30. Age, experience, and expertise ratings showed some tendency toward older participants having more years of experience and higher self-ratings for expertise, but there were also younger participants with more years of experience and higher self ratings of expertise. Of the three youngest participants, two rated themselves toward the low end of the expertise scale, while the other self-rated as a seven. The self-ratings did not appear to be entirely accurate, with some ratings possibly higher than is realistic and some possibly lower, as discussed in section 5.11.1. Better estimates of expertise would require additional data. It was noticeable that no one wanted to rate themselves as a one, even for participants who were involved in their very first instructional design experience with very little associated training. Several participants stated that they didn't want to be a one, two, or too low.

Ethnicity was heavily weighted toward white/Caucasian, but ethnicity and also gender did not appear to play a role in the study. The primary demographic distinction was that senior, experienced faculty were more likely to be involved in large, complex, interdisciplinary design efforts. However, more senior, experienced faculty were available during the summer because they were on campus to work on special projects they did not have time for during the rest of the school year. Several senior faculty mentioned wanting a break from quiet and somewhat isolated summertime campus environment to do an interview. During the school year more faculty and graduate students are on campus, and there would be more people and a wider range of people involved in large, complex projects.

There were differences between participant responses with respect to experts and novices, with instructional design experience, subject matter expertise, and type of course as other major factors (discussed elsewhere in this chapter and Chapter 5), but these issues did not have clear connections to demographics beyond the general tendencies discussed above. A caveat for interpretation of demographic data beyond that mentioned above is that this study only looked at early conceptual design, but captured a huge range of design issues and experiences, many of which were unresolved and ongoing. Comparing demographic data across, for example, someone whose design experience involved four steps, substantial subject-matter-related concerns, and several solved problems with indication of successful design to someone who had ten steps addressing a very complex situation focused on recruitment of corporate subject matter experts with as yet no design resolution, does not provide a fair basis of comparison. There are simply too many variables involved to justify further analysis of demographic data, especially for incomplete design efforts.

This perspective fits with the researcher's observations from industry, where experience, expertise, type of design and attitude were generally the major factors in approaches to design. Attitude was a very consistent aspect of this study, as all participants were enthusiastic about sharing their instructional design experiences.

The study would be stronger if more novices and younger participants were included, but that concern is balanced out somewhat by the fact that all participants were involved in design situations that were new to them, placing them in a novice role to an extent. The novices who were included provided excellent data.

3.4.1.1 Limitations of Sampling Implementation

The majority of data collection was performed during the summer from a limited population of available faculty. As discussed above in section 3.4.1, this resulted in more interviews with senior, experienced faculty than with novice faculty.

A lesson learned for future research is to plan for a wider range of recruitment options by contacting potential institutions in advance to determine the expected norm for research involving faculty. The majority of recruitment contacts were made via approaches that were not the norm for the department(s) involved. This negatively impacted the perceived credibility of the study.

3.5 Establishing Data Saturation

Saturation for this study was defined as the point when no new substantive types (kinds) of questions were still being found, within reasonable constraints based on the general instructional design environment, data collection time frame, and nature of the research. In section 0 it was determined that it was reasonable to expect to see regularities in data by the 10th interview as a minimum starting point for evaluation of data saturation, provided that at least two educational institutions, a range of academic disciplines, and a range of approximate participant expertise were taken into consideration.

At interview 10 regularities in the data were seen within data categories and across participants. More than two educational institutions were involved with nine academic disciplines across the 10 participants. However, participants were largely very experienced senior faculty and substantive new coding directions were still being identified. As data was more complex than anticipated due to the preponderance of experts involved in complex special projects, this was not a surprise. Recruitment was continued with increased focus on novices and additional academic disciplines.

By participant 17, substantive new types of questions were no longer being identified. Changes to the codebook were minor, primarily for clarification or enhancement of existing codes. Several novices had been included. Ongoing data analysis showed that adequate data existed for comparison across participants. One more interview was already scheduled for the following day and was completed to bring the total to 18 participants and 157 questions (average of 8.72 questions per participant) across an acceptable range of expertise, disciplines, subject matter, and institutions. Data saturation was reached and data collection was ended.

3.6 Means of Establishing Reliability and Validity

Descriptive research is interpretive, typically involves analyzing data for categories, and always involves some level of personal interpretation by the researcher. Reliability and generalizability have more minor roles in qualitative research, with validity based on whether findings are accurate from the standpoint of the researcher, respondents, or readers (Creswell, 2003). Refer to section 3.7 for information on generalizability.

Validity/credibility can be improved through use of rich description, clarification of researcher bias, inclusion of negative or discrepant data and results, and focusing on how people make sense (Creswell, 2003). There is not necessarily a correct answer in a sense-making research situation, reducing emphasis on validity. Reliability can be addressed to an extent by monitoring responses to see if similar data is obtained across respondents. Validity can also be improved in qualitative research by establishing the value of the researcher's identity and experience to the research, a form of "critical subjectivity' to apply the researcher's experience as part of the inquiry process (Maxwell, 2005).

3.7 Means of Establishing Generalizability: Design Mapping

This section discusses the means of establishing generalizability for the study. The ad-hoc design mapping analysis that was used to explore transferability to other design domains and partial proof of concept for design as a discipline is outlined. Details of the design mapping analysis are provided in Appendix O with results in section 4.9.

3.7.1.1 Generalizability

Quantitative research generalizes from a sample to the population and qualitative research applies ideas across contexts. In qualitative research *transferability* refers to evidence supporting generalization of research findings to other contexts. Transferability is strengthened by detailed descriptions that enable comparison with and judgments about a "fit" with other contexts, especially if it can be shown that the same ideas apply more widely and are applicable in other fields (Suter, 2012).

This perspective on generalization of qualitative research is a good fit for this study. Criteria for generalization and transferability are: findings, other contexts, ideas that transfer widely and to other fields, and evidence supporting generalization of findings to other contexts (Suter, 2012). The approach to generalization taken in this study is outlined in Table 5.

Table 5. Generalization Criteria & Design Mapping Analysis

Generalization Criteria	Ad-hoc Design Mapping Analysis
Research Findings	Questions and question context from early conceptual instructional design in higher education provided detailed descriptions for comparison with questions asked in other contexts.
Other Contexts	A variety of design domains across multiple fields.
Idea Supporting Transferability	Design as a discipline: the idea that there are design commonalities across all areas of design
Evidence	Results of the ad-hoc design mapping analysis.

The idea of design as a discipline supports transferability across contexts for this study. The existence of commonalities in question-asking behavior during design across multiple design disciplines supports the concept of design as a discipline. Study data showed patterns of question-asking and designing behaviors. These behaviors can also be understood in the context of the core elements of design, those that reach across disciplines and design domains.

The overarching goal of the study is to support future research on interventions to aid designers from *all disciplines* with question-asking during design. The interventions of interest are techniques applied in commercial nuclear power. Showing transferability across nuclear power and other design contexts can help refute the argument that 'nuclear power is nothing like what I do'. The ad-hoc design mapping analysis ties to all of the ROs, further strengthening generalizability.

3.7.1.2 Ad-hoc Design Mapping Analysis

Design mapping is a strategy for revealing a complex of relationships between design representation and thinking, technology, culture, and aesthetic practices, often focused on visualization of data and ideas (Newman, 2013). Application of design mapping to identify commonalities across design domains for question asking supports the concept of design as a discipline. Successful design mapping to commercial nuclear power can reduce the amount of research required to transition from descriptive studies of question-asking behavior to future research on interventions to aid designers with question asking.

Design mapping of question data to similar questions in design domains other than instructional design in higher education provides insights on how the question-asking behavior of faculty during early conceptual design is similar to question-asking behavior in other design domains. Some best practices from other design domains were shared. Refer to sections 4.8, 5.8 and Appendix O for more information.

3.8 Research Procedures

This section discusses the research procedures including development of the interview protocol, interview design and item construction, data collection, and data analysis. Previous pretesting and pilot testing of the interview protocol are discussed in Appendix D.

3.8.1 Development of the Interview Protocol in the Context of the Research Questions

This section discusses how the interview protocol was developed to support investigation of the research questions. First the general development of the interview protocol is discussed. Next, each section of the interview protocol is covered in the order used for the interview. The associated research objective(s), the purpose of that section and the procedure used are described. Portions of the interview protocol that do not directly support a research objective but provide support to other aspects of the study are also explained.

A neutral questioning technique interview protocol was developed for use in the study. The initial interview protocol was based on an interview protocol used in pre-testing and pilot testing of the original dissertation proposal. The revised interview protocol in Appendix E incorporated lessons learned from previous pilot testing and a refocusing of the interview questions. Participants' responses were kept strictly confidential. Personally identifiable information was removed from the data and will not be shared with anyone else or published in any form. Results were aggregated and presented as averages or trends of what many people think or believe.

Prior experience developing Sense-Making interview protocols for class research projects and research practica was helpful in developing the interview protocol. The protocol was carefully worded to avoid leading respondents or taking them out of the context of their own instructional design life experience. The interview was designed to be a conversation with the participant. The interview protocol included both the questions asked of the respondent during the interview and prompts to consistently guide the researcher through the interview. This helped ensure that interviews were conducted in the same way for all respondents, improving reliability and replicability.

One logistical change was made to the interview protocol that is different from previously used protocols. The previous protocols were designed to use index cards for some portions of the data collection, with other data documented on the interview protocol itself. This required maintaining both an interview protocol and a set of index cards for each participant. It can be difficult to go back and forth between paper and index cards while taking notes and talking to the respondent during interviews. Therefore, the current interview protocol was designed to permit one master copy of the interview protocol to be used by the researcher as a reference during interviews, while all data is collected on index cards. This approach worked well.

Protocol wording was revised for clarity and brevity and to better guide the researcher during the interview process. The item numbering scheme was simplified and prompts for index card content were added.

3.8.1.1 Interview Protocol Design and Item Construction

This section explains how the interview protocol was used to identify and collect data to describe the participant's instructional design situation and answer the research questions. Each section of the interview protocol is described in detail. The interview protocol followed a standard approach to Sense-Making interviews, eliciting data from users on steps, questions, basis for questions, helps, hurts, answers to questions (if any), sources of questions, and big picture data. The protocol also collected basic demographic data and participant's ratings of their instructional design expertise in order to show that a range of respondents was included in the study.

3.8.1.1.1 Section One: Overview and Actions (Steps)

Before the interview can begin, the participant must voluntarily agree to participate and sign the informed consent form.

Section One – Overview:

PURPOSE: The Overview portion of the interview protocol does not directly satisfy any of the research objectives, but was critical to set up the scope of the remainder of the interview. The Overview provides context for the instructional design experience, familiarizes the participant with the interview approach, and provides the participant with practice at communicating their experience in chronological steps. Researcher experience has shown that many people are not familiar with trying to explain their experiences in a step-by-step manner. After a few steps, participants tend to get the hang of this process and are comfortable telling their story. Researcher patience and empathy is important during this phase of the interview to reassure participants who may initially be nervous about being interviewed.

OVERVIEW PROCEDURE: The Overview begins by focusing the participant's attention on a specific recent situation when an instructional experience or instructional materials needed to be designed for any of the following:

- A cross-disciplinary course or lesson
- A topic you were not very familiar with
- To create a type or means of instruction you had not tried previously

This ensured that the requirements for the research context were met.

Next the interviewer explains to the participant that the purpose of the interview is to "*understand your entire thought process associated with the earliest part of your instructional design experience, when you were just getting started. We want to understand what happened first in your thinking, what you thought and did, or what just happened. You can choose a specific lesson or instructional material -- it does not have to be an entire course design. Remember that we only want to look at the early part of your instructional design experience, when you were first trying to figure out what to do and think about*."

Then the general interview process is explained, including: a comic strip metaphor to help participants grasp the concept of breaking a life experience into sequential action-oriented steps, the iterative nature of the interview,, and the use of index cards to document responses and provide a visual aid. This helps focus the participant and clarify expectations. The interviewer must work to maintain an appropriate level of detail throughout the interview by patiently prompting for clarity and completeness as needed, while politely keeping the participant from getting sidetracked.

Section One – Actions (Steps):

ASSOCIATED RESEARCH OBJECTIVE: Data collected in Section One – Actions (Steps) of the interview protocol contributes to satisfaction of RO3:

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

PURPOSE: To elicit data on actions taken by the participant (Steps) during the instructional design experience.

PROCEDURE: Situate the participant at the very beginning of the instructional design experience by asking "*Thinking back, what was the very first thing that happened, or the first thoughts that you had in your instructional design experience?*" This provides the first step in the instructional design experience. Next, general situational data on the instructional design experience is requested, including subject matter, platform (classroom, online), prior experience with the subject matter, and whether the subject was cross-disciplinary.

The interviewer asks ""*What happened next?*" and continues collecting step data until the participant feels that the documented steps are adequate to bound the 'getting started' portion of the instructional design experience. Interviewer experience with Dervin's methodology, this interview technique, and instructional design helps to determine when to prompt a participant about whether an appropriate stopping point has been reached. Too many prompts could give the participant a negative impression. Too many steps may result in excessive interview length and scope beyond the beginning of conceptual design. All steps must be part of conceptual instructional design. If participants wanted a longer interview and time and institutional policy allowed, interviews longer than 30 minutes were conducted (some institutions place strict time limits on faculty interviews).

3.8.1.1.2 *Section Two: Cognition (Questions)*

ASSOCIATED RESEARCH OBJECTIVE: Section Two of the interview protocol partially satisfies RO1 and contributes to satisfaction of RO3:

RO1: To explore questions faculty ask during early conceptual instructional design.

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

PURPOSE: Identify questions the participant had during the specified conceptual instructional design experience. Questions are the operationalization of gaps, per Dervin's methodology. Gaps were the unit of analysis for the study, operationalized generally as questions or concerns. Dervin's updated model has expanded the operationalization of gaps to also include confusions, muddles, riddles, angst, and emotions that pause or stop an individuals' forward progress through time and space (B. Dervin, et al., 2011; B. Dervin & Reinhard, 2006). Questions asked of self or others and declarative statements of concerns are considered to be indications of an information gap or need. Dervin's approach views a concern as a question that was not actually asked out loud, leading to questions and concerns being referred to together as “questions.” (B. Dervin, 1983; B. Dervin & Clark, 1999; B. Dervin, et al., 2003b).

PROCEDURE: Questions are identified and isolated via the interview protocol by starting with Step 1 of the participant’s instructional design experience, and proceeding through the steps chronologically. For each Step, ask the participant to *“tell me if you had any questions or concerns RELATED TO the instructional design experience at THIS point and by question, I mean anything you wanted to find out about, were confused about, or were just curious about. This doesn’t have to be something that you actually asked about out loud or that you actually got an answer to. So think back to* STEP *<<respondent’s step>>, and tell me what questions or concerns you had. If a thought or feeling is the same as it was earlier, please say so. Did you have any questions, concerns, or confusion at this point in your instructional design experience? … Any other questions at this point in your instructional design experience?”* This process collects participants’ actual questions and concerns in their own words. The interviewer may prompt participants for additional information as needed to determine questions/concerns experienced by the participant. Data gathered in Section Three permitted additional exploration of these questions.

Any questions or concerns that the participant had during the conceptual design experience actions (steps) established in Section One were acceptable as question data, provided that they were in some way related to the conceptual instructional design experience. This isolated conceptual instructional design-related questions for further data collection and data analysis. If necessary, the interviewer prompted for clarity to determine if a question was really part of the conceptual instructional design process.

Researcher experience has been that a carefully developed and tested interview protocol applied by a reasonably experienced interviewer will keep the participant focused on the specific instructional design experience. Extraneous questions are not usually a concern.

3.8.1.1.3 Section Three: Question Loop

ASSOCIATED RESEARCH OBJECTIVES: Data collected about Uses in Section Three of the interview protocol satisfies RO2 and contributes to satisfaction of RO3:

RO2: To identify uses that faculty associate with the questions they ask during their conceptual instructional design experience.

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

PURPOSE: Collect data to provide additional context for the questions identified in Section Two of the interview protocol.

PROCEDURE: For each step, starting with Step 1, the following items are covered for each question associated with that step:

BASIS: The basis for questions (why a question was asked or thought about):

Ask: "*Now we'll look more closely at each of your questions. I will ask you what may appear to be repetitive things, but please bear with me and remember that what we are trying to understand is different as you move through your experience and is very important to us. If a thought or feeling is the same as it was earlier, please say so. First, I'd like you to think back to*

STEP <u>*<<respondent's step>>*</u> *when you had this question/concern* <<Read QUESTION>> *and tell me what led you to think about or ask that question – what the basis for that question was."*

USES: Uses of questions (operationalized as positive helps and negative hurts)

HELPS: *"When you had this question/concern* <<Read QUESTION>> *"AT THAT TIME, was there anything specific you can think of that helped you to design your instructional experience and understand the issues involved, such as resources, people, activities, ideas, thoughts, or anything else?"*

HURTS: *"When you had this question/concern* <<Read QUESTION>> *AT THAT TIME, was there anything specific you can think of that got in the way of your ability to design your instructional experience, or kept you from understanding the issues that might be involved?"*

ANSWERS: Answers to questions (if any). As details on answer content were less important for the purposes of this study than whether an answer was found, how complete the answer was, or if the answer helped or hurt, detailed answers were not elicited. Responses to these items were obtained as no (didn't ever or didn't try), yes, partial, or complete. If an answer was found, the source of the answer and how the answer helped were documented.

Ask: *"Did you actually get an answer to this question/concern AT THAT TIME? If so, from what source? How did the answer help?"*

"Did you EVER get an answer to THIS question/concern?"

SOURCES: Sources of questions (an operationalization of resources).

Ask: "*And what was the source of that question? By source, I mean where did you get the question from? For example, your own memory, a reference book, another person, the Internet, etc.*"

3.8.1.1.4 Section Four: Demographics

PURPOSE: Demographic data does not directly satisfy any of the research objectives, but is important to illustrate the range of participants. Demographics included age range, ethnic background, gender, self-reporting of expertise level performing design of instruction (Likert scale, novice to expert), and years performing design of instruction.

Self-reported data on expertise level and years performing design of instruction was used only to show that a range of participants were included in the study

PROCEDURE: Participants were informed that demographic data is used only to show that a range of participants was included in the study. Participants were asked to provide: age range, ethnic background, experience level with designing instruction on a scale from one to ten where one is a novice and ten is an expert, years of experience designing instruction, and gender.

3.8.1.1.5 Section Five: Cognition (Big Picture)

ASSOCIATED RESEARCH OBJECTIVE: Interview items 1 through 4 of Section Five of the interview protocol satisfy RO4:

RO4: To explore what faculty feel is important about question-asking during instructional design.

Interview item 5 of Section Five of the interview protocol does not necessarily satisfy any of the research objectives, but may identify possible directions for future research.

PURPOSE: Collect data on big-picture issues associated with question-asking during conceptual instructional design. It is typical to have a big picture item in a Sense-Making interview. This provided participants with an opportunity to share important information about their thoughts, activities, or feelings related to their conceptual instructional design experience that are not covered by other interview items. This tends to make the interview process more personal.

Interview items 1 through 4 of Section Five of the interview protocol were intended only to provide an initial general exploration of what faculty feel is important about question-asking during instructional design. These questions were intentionally very broad and may result in less valid data than the rest of the interview protocol. For the purposes of this initial exploratory study, this was an acceptable approach to obtaining limited rich data about the importance of question-asking and questions during instructional design. Instructional design is generally a fairly complex activity involving quite a few questions over a relatively long term. A full investigation of perceived value of question-asking and questions is well beyond the expected scope of dissertation research. Obtaining even quite limited big-picture data on the importance of question-asking and questions during instructional design resulted in interesting data that supported current research and pointed to new directions for future research.

Interview item 5 provided participants with an opportunity to express additional insights on their instructional design experience. It also provided some information on participants' level of experience, expertise, or background, enriching the demographic data collected. Similar to interview items 1 through 4, this resulted in less valid data, but was acceptable for an initial exploratory study for the purpose of identifying new directions for future research.

PROCEDURE: The following questions were asked of the participant:

1. *"Is there one thing you feel is most important about questions to ask during instructional design, or something you are curious about?"*
2. *"Is there a question you wish you had asked?"*
3. *"What questions do you think are most important to ask yourself when designing instruction?"*
4. *"How does it make a difference in the quality of instruction as compared to when you overlook or leave out questioning?"*
5. *"Is there anything else you'd like to tell us about how this instructional design experience has affected you?"*

3.8.1.1.6 Section Six: Post-Interview Feedback

PURPOSE: Section Six of the interview protocol does not satisfy any of the research objectives, but was one way the study provided benefits to participants as established in the Syracuse University Institutional Review Board submission for the study. This section also helped the researcher identify additional directions for future research.

PROCEDURE: If the respondent was interested (all participants were), some possible benefits of question-asking during design were discussed. Possible benefits included (Oliva & Hubbard, 2015):

- Jog memory – less chance of forgetting something important
- Reduce cognitive load – provides an external reference that compensates for human limitations in mental visualization, supports systematic iteration, helps designers notice new design elements, and helps designers handle different levels of abstraction simultaneously (such as details and big picture concerns).

  An example from nuclear power of reduction in cognitive loading through use of external references is the inclusion of more detail in operating and maintenance procedures in terms of descriptions of expected outcomes, inclusion of visual aids in the text and visual clues on the equipment itself (Hubbard, 2015a).
- Helps people deal with uncertainty. Questions help to chunk complex design into more easily manageable pieces, and provide pathways to investigate a wide range of options. Exploring options can help to identify potential solutions and concerns, reducing overall uncertainty.
- Reduce the potential for design fixation. Design fixation is focusing on a single design solution early in the design process, which can prevent people from identifying multiple solutions and keeping design options open. Design fixation often leads to poor design solutions.

  Per Hubbard, an example of the practical result of design fixation is the Three Mile Island nuclear power plant accident. Operators fixated on the Auxiliary Feedwater motor operator valve position, which was indicating the correct open position. No one thought (until after the meltdown) to check the positions of the

> manual valves in the system because by design they were supposed to be open (they were closed) (2015a).

Participants were then asked if they would like to receive a copy of the study results when available. At this point the formal interview process was complete. Opportunity was provided after completion of the interview to discuss the dissertation research if desired, another opportunity for potential benefit to participants.

This completes discussion of the interview protocol. The next section covers data collection.

3.9 Sense-Making Data Collection

This section covers the data collection process, documenting data, issues associated with use of the timeline interview, and maintaining confidentiality for sensitive data.

3.9.1 Data Collection Process

Data collection was performed following the guidance provided in the interview protocol. To avoid curtailing an interview while participants were still providing useful information, participants were notified during the interview scheduling process that complex topics or topics requiring substantial explanation of context could take longer than 30 minutes, and that opportunity would be provided after the data collection to discuss the dissertation research if desired. The researcher was careful not to schedule back-to-back interviews, and to check with participants about how much time they had available prior to beginning an interview. This worked well.

Prior to beginning the data collection interview, voluntary written informed consent was obtained from participants, including permission to audio record the interviews. Refer to Appendix G for the approved consent form. The purpose of the interview was then explained. Opportunity was provided for the participant to ask questions.

A lesson learned for future interview protocols is that it's helpful to let participants know up front that if there is anything in the design experience that they REALLY want to share and we don't cover it in the interview questions, they will have the opportunity to share it at the end of the interview. That reduces the potential for participants to focus on what they want to discuss versus responding to the questions they are asked.

Participants were asked to describe a recent instructional design experience using an open-ended interview format that permitted them to tell their own story of what happened (refer to section 3.8.1). The questionnaire obtained data in the participant's actual words, reducing the potential for researcher misinterpretation of data. To ensure adequate detail, the questionnaire included prompts for clarity and completeness.

Demographics were optional, but were not refused by any participant. All but one participant requested a copy of the study results (that individual was about to retire at the time of the interview). One participant requested a copy of the final dissertation.

The next section discusses the means of documenting data.

3.9.2 Documenting Data

Data was documented using index cards, a digital clipboard (DigiMemo System), and audio recording. One issue noted in previous timeline interviews was that although individual index cards are easily sorted, arranged, and shared with participants, they are small enough to easily get out of order during an interview and have limited writing space available. It was decided to try using fanfold form-feed 4" x 6" index cards in sheets of three to provide additional writing space and easier organization. That still permitted separation into individual index cards if the participant wanted to see them and manually organize them as a memory aid during the interview. Form-feed index cards can be pre-labeled using a dot matrix printer. This worked nicely.

The digital clipboard could upload data files directly to Word and Excel to minimize the amount of transcription required, and provided redundancy for written data. However, it's highly dependent on the researchers' ability to print neatly, maintain a linear data stream (due to a rigid digital pagination structure), and remember to advance pages when needed. The digital clipboard had a clip failure during the second interview, forcing awkward use of a binder clip from then on. The digital clipboard was good for data redundancy/peace of mind, but a digital pen would probably be more effective.

Audio recording was optional, but was not refused by any participants. Audio recording was extremely helpful due to the large amount of information communicated by respondents during interviews. It's difficult to maintain the interview as an engaged conversation while trying to write down every word. Audio recording was performed using a Philips digital voice recorder. No problems were experienced with the audio recording except once when the recorder was accidentally turned on while inside a book bag and ran down the batteries. This problem could be avoided by obtaining a hard case for the recorder.

Issues due to use of the timeline interview are discussed next.

3.9.3 The Timeline Interview as One Piece of the Puzzle

Participants were interviewed about an aspect of an instructional design situation that was new to them, generally resulting in discussion of one portion of a larger instructional design effort. Interviewing designers who were currently in the middle of a large design project and/or very complex design situation tended to take more time than for a simpler, more straightforward design situation, sometimes considerably so. Questions asked during the timeline interview sometimes required the participant to think about his or her design process in new ways.

Thinking in terms of steps/questions/question context was a new approach for most people. Participants may initially be confused about describing their actions as steps. Use of index cards as a visual aid helped them to envision their 'comic strip,' and after a few steps they grasped the process. Similarly, explaining details of question context may initially cause some anxiety, particularly for helps and hurts. Participants become familiar with the process after the first few question loops.

Discussion of one part of a larger design experience may require explanation of past and current design context and anticipated future design direction for the researcher to fully grasp the difficulties and opportunities involved. Sensitive information sometimes came up, especially during discussion of question context. That can cause anxiety. The approach for dealing with sensitive information is described next.

3.9.4 Maintaining Confidentiality for Sensitive Information

The summertime data collection timeframe resulted in a small sample size of 18 participants. Many participants were very experienced faculty who were on campus to work on large special projects. Design efforts were sometimes so specialized that extra caution was needed to ensure that confidentiality was maintained.

The small sample size required establishing an approach to maintain data confidentiality and reassure participants. If possibly sensitive information arose, the policy followed was to explain to the participant that while that data might be acceptable to use in a much larger study where it would be one experience out of many, because of the small sample size no sensitive or controversial data would be shared. All data files were carefully reviewed to ensure that possibly sensitive information was not transcribed or included in the final dataset.

The next section discusses transcription and data entry.

3.10 Transcription and Data Entry

Data entry and transcription was performed in several phases:

1. Setup of an Excel spreadsheet for data analysis. Each participant was assigned an identification number (ID) to maintain data confidentiality. As is typical for analysis of Dervin's Sense-Making timeline interviews, the questions asked in data collection interview established the column/field headings for the data. See Figure 9 below.
2. Written participant data from the index cards used in the data collection interviews was typed into corresponding record/fields in the Excel spreadsheet. Sensitive data was excluded as agreed upon with participants.
3. Audio data was reviewed and relevant data was transcribed using F4 transcription software and a transcription foot pedal. Lengthier interviews sometimes contained

information that was not relevant. That was especially true for interviews in which the participant needed to talk through multiple peripheral aspects of the design experience in order to determine how to respond to an interview question. An example is talking in detail about a series of past experiences in an effort to determine how to best explain the triggering experience that inspired the current design effort. Information pertinent to the data collection interview questions was transcribed. Sensitive data was excluded as agreed upon with participants.

4. Transcribed data was entered into the Excel spreadsheet.
5. The data spreadsheet and audio files were reviewed before distributing data for design mapping and intercoder reliability coding to ensure that data confidentiality was maintained and to recheck content for relevance. Some additional context was incorporated with minimal editing to maintain confidentiality.

A	B	C	D	E	F	G
ID	Subject Matter	Classroom or Online?	Prior Experience?	Cross-Disciplinary?	Step	Step Descriptions

H	I	J	K	L	M	N
Question Number	Question Description	Basis for Question	Helps	Hurts	How an Answer Helped	Source of Question

O	P	Q	R	S
Most Important about Questions	Question I Wish I'd Asked	Most Important Question to Ask Self	Quality?	Other Effects of the Design Experience

T	U	V	W	X	Y
Age	Ethnicity	Experience Level. Instr. Design	Years of Instr. Design	Gender	Copy of Results

Figure 9. Sense-Making Data Fields

3.11 Initial Data Analysis

This section discusses initial data preparation, coding, and analysis. Data analysis consisted of deductive and semi-inductive content analysis, descriptive statistics, and design mapping. Data analysis was performed in Excel and MAXQDAPlus, with Wordle.com used to generate word frequency visualizations.

3.11.1 Initial Data Preparation

The timeline interview questions were designed to correspond to specific sense-making analysis categories such as steps, questions, and question context (basis, helps, hurts, etc.). The interview questionnaire determined the data 'groups' that became the field headings in the data analysis spreadsheet. A response was considered to be all of a participant's words in reply to a specific interview question that were related to that interview question. Little or no additional parsing was required. Every column in the spreadsheet, with the exception of participant ID number, corresponded directly to an interview question specifically designed to elicit that data per Dervin's conceptual framework. This is typical for Dervin's timeline interviews. This approach is different from typical content analysis for an interview, in which a large transcript is analyzed and segments are parsed out for coding.

Initial data preparation consisted of setting up data columns in an Excel spreadsheet for each timeline interview question, entering initial data, and then inserting coding columns in the Excel dataset. Fields were set up for interreliability coding of: *Steps*, *Questions*, *Basis for Question, Helps, Hurts, Answer, Source,* and *Big Pict*ure data.

As data collection interviews were conducted in parallel with data analysis, initial coding was begun when three interviews had been completed.

3.11.2 Initial Data Coding and Analysis

Data was first coded using a typical deductive content analysis approach for sense-making data: initial coding using Dervin's 5 W's and an H approach - categories of *Who, What, When, Where, Why* and *How* (B. Dervin, 1983). For this study, 'Why' is the *Basis for Question* data. This framework helped maintain a broad perspective during initial coding. Dervin's Five W's and an H approach is typically followed by what is commonly referred to as inductive content analysis (Brendlinger & Dervin, 1999;

Schamber, 2000), but technically is not truly inductive content analysis. Dervin's categories from the timeline interview template and the 5Ws and an H are the starting point. It's more appropriately a form of semi-inductive content analysis (Towne-Roese & Taylor, 2013), applied to code participants' responses in an inductive manner within the data structure established by the timeline interview.

Semi-inductive content analysis of timeline interview data typically identifies issues such as resources, time, actions, understandings, emotions/self-image/motivation, situational descriptors, answers, problems, or concerns. Behaviors such as iteration are considered patterns that arise from the data, and are not part of initial coding.

Interestingly, coding complex design data with the 5Ws and an H was a very different and more useful experience than coding simpler, linear data, where application of the 5Ws and an H may be quite obvious. Early in initial coding it became apparent that some complex data was difficult to classify within the 5Ws and an H. As a result, semi-inductive coding was begun. As additional data was collected and analyzed, insights obtained during semi-inductive coding helped to clarify complex data, establish coding rules, and work out appropriate classifications within the 5Ws and an H. An example is coding of 'how much' questions, which often look like a *How*, but are actually a *What*. This distinction can be tricky when complex situations are described by participants in ways that do not necessarily include the words 'how much.'

Data analysis was expected to be an emergent process at this stage due to the large number of unknowns, the complexity of design data, and the lack of much prior research in this area. Some deductive content analysis was periodically required for data not yet classified for 5Ws and an H. Later, as intercoder reliability coding progressed, the work done clarifying the underlying structure of the 5Ws and an H was very useful as a basis of discussion for resolution of coding disagreements.

Additional Sense-Making categories were added as more data was collected, including *resources* (relevant to bridging a gap), *verbings* (Sense-Making and Un-making actions while trying to bridge a gap), situational categories (*stops*, *barriers*, and *constraints*), *attitudes* and *emotions* (bridging gaps), and *goals* (B. Dervin, et al., Editors, 2006). Refer to Figure 4.

The intent during initial coding was to maintain trueness to participants own words as much as possible. Initial data analysis was completed prior to coding for issues based on the researcher's own experience or the literature, or issues that require a higher level of analysis across multiple items or participants. A good example of a design issue that requires a higher level of analysis is iteration, which requires reviewing all of the data for a participant as a whole to try and find instances of repeated steps and/or questions.

Examples of some emergent topic areas included: interaction with peers, inclusion of administrative policies, learning whether a design idea will work by running a pilot class to test both instructional method and a hands-on design project, and receiving guidance from external industry employers.

By the time six interviews were complete, the data contained a broader range of subject matter and design experiences. Initial coding had been completed for the available data, and there were indications of some higher level design issues such as concerns about cross-disciplinary instructional design and implementation of related instruction. An initial codebook was developed. Up to three codes per response were permitted.

After interview six, data was reviewed and determined to be valid. Some basic patterns and indications of reliability appeared such as similar steps and questions across participants (examples: I talked to a peer. I looked for materials and references online. How do I know it's working? I'm concerned because I need to know more about the topic.). This was a good indication that the interview protocol design was sound, but there was not enough data to begin interreliability coding.

All interviews were performed in private offices or private conference rooms. The detailed interview script was followed closely, with the same script used for all interviews. This helped ensure validity.

Researcher bias can never be eliminated completely, but focusing on the participants wording and trying to view each item as a stand-alone was helpful to maintain objectivity. Preceding the emergent coding with Dervin's 5 W's approach was useful to objectively refocus on the data and, to the extent possible, separate the data from the sometimes emotional experience that Jeffress and Porter have stated a timeline interview can be for the researcher (Jeffress, 2013; Porter, 2010).

Next, additional potential coding categories were determined by grouping and examining similar responses and applying researcher's expertise and results of literature review. This identified several areas with potential for more in-depth analysis. Planning was also underway for design mapping.

At this point, the general coding process was established and would continue in parallel with data collection and analysis. However, a major decision had to be made about how to implement intercoder reliability coding. An intercoder reliability of 90% minimum was anticipated as satisfactory for the proposed study. The following section discusses intercoder reliability in detail.

3.12 Intercoder Reliability

This section discusses intercoder reliability including a test run, Intercoder Reliability Phase 1, and Intercoder Reliability Phase 2.

Intercoder reliability addresses reproducibility of data coding across a minimum of two equally capable coders to determine if two coders working independently will code the same units or characteristics of data in the same way. After intercoder reliability coding is performed, coders then attempt to resolve coding discrepancies through discussion to determine the level of intercoder agreement using a numerical index. A separate pilot test may be used to assess reliability during coder training prior to performing reliability coding of the full sample of data (Campbell, Quincy, Osserman, & Pedersen, 2013; Lombard, Snyder-Duch, & Bracken, 2002). As an exploratory study intended to provide a basis for future research, with no similar study to reference, establishing intercoder reliability and agreement is important for credibility.

Two coders were recruited early in the data collection time frame to assist the researcher with interreliability coding: Coder One and Coder Two. Criteria for selection of coders included experience with content analysis, instructional design, and Dervin's Sense-Making methodology. Individuals who had taken the Syracuse University iSchool's IST 641 User-Based Design course or have other experience with Dervin's approach were preferred. At that time it was anticipated that much of the data would be obtained from novice instructional designers.

By the time adequate data was collected to begin coding, it was apparent that the early data collection time frame resulted in a majority of expert participants, including fairly complex cross-disciplinary situations and a wide range of subject matter. This was quite different from what had been anticipated. I was concerned that some of the data might be outside coder's experience. Planning for a design mapping pilot test touched on the cognitive gymnastics that can be required to analyze complex cross-disciplinary design, even for design as a discipline experts. There is no substitute for cross-disciplinary design experience. At this point an intercoder reliability test run was initiated.

3.12.1 Intercoder Reliability Test Run

An initial codebook was developed containing the full range of current codes, from the 5 W's and an H to the higher level codes and iteration. The codebook was not fully defined at that time, but I wanted to expose coders to a range of potential issues to help identify problems up front. Coding-ready data from the first six interviews, raw data (if needed for reference), codebook, and instructions were provided to both coders. While big picture questions did not require intercoder reliability estimates, coders were asked to optionally provide general coding of a few of the big picture items. Refer to Appendix H and Appendix I for the instructions and codebook used for this test run.

Only Coder One was available for coding at that time. Coder One coded a small portion of the pilot data (approximately half of one interview). Results were very useful for refining both the codebook and the intercoder reliability approach. Issues raised included (in no particular order):

1. Not finding an appropriate code, possibly due to not understanding the code definition.
2. Unfamiliarity with Dervin's timeline interview technique. The items/questions in the timeline interview protocol establish the field headings for the data, and the responses are the data to be coded. This can confuse coders used to content analysis that starts with parsing a narrative, which generally has a storyline from which segments are pulled for coding.
3. The codebook was flat. I learned in IST 641 to purposely defer grouping within the codebook in order to focus on coding at the detail level first. When reasonable agreement on coding is reached, grouping begins, working both within and across the high-level groupings established by the interview questions. This approach was unexpected and confusing for the coder.
4. The coder requested samples of my data coding for each code rather than the general examples that had been provided. This was problematic, as some codes currently applied to only one instance, and I didn't want to bias the coders' work.

Background information on typical coding approaches for timeline interview data was provided to coders to clarify these issues. Information was provided on data context, use of the interview protocol, how field headings tie back to the interview protocol, use of a flat codebook, and performance of data collection, coding and analysis in parallel. This concluded the test run.

3.12.2 Intercoder Reliability Phase 1

Prior to beginning the first round of coding, which contained 14 interviews, all audio files were reviewed to make sure nothing of use had been missed. Data was reorganized to make context clearer, and better examples were provided for coding including samples of my own coding for two rows of code in the data spreadsheet. Data culling had to be performed for some interviews to maintain confidentiality due to the small sample size, but care was taken to preserve context.

It was decided to break coding into two phases. Phase 1 included coding of *Helps Hurts, Answer, Source* and *Big Picture*. This would help coders become familiar with the data before tackling the more complex coding of *Steps, Questions*, and *Basis for Question* in Phase 2. All coding was done remotely using Excel spreadsheets.

The codebook for Phase 1 consisted only of codes already in use for the designated categories. The codebook was refined and grouped per the emergent data codes to provide some structure for coders and instructions were rewritten (refer to Appendix J). All data for each designated category was coded. While it is more the norm to start by coding a percentage of the data, by this time it was apparent that interdisciplinary design experience was playing a bigger role in coding than anticipated. This was due to the much larger than anticipated number of expert participants working on complex special projects. If only a percentage of the data was coded, the diversity of the data could result in misleadingly high intercoder reliability agreement percentages.

When coding was complete, the percentage of intercoder reliability agreement was determined by comparing my coding to the coders work using the Resolution columns. For each coding mismatch, I documented the reasoning behind my coding decisions in my Resolution column. Data was then returned to the coders with instructions to use their resolution columns to either indicate agreement or explain why they did not agree. The percentage of agreement for each coding category was then calculated by dividing the number of unresolved mismatches by the total number of coded items in that category. Refer to Appendix L for intercoder reliability calculations.

Intercoder reliability agreement percentages for Phase 1 Round 1, independent coding only, are shown in Table 6.

Table 6. Phase 1 Round 1 Intercoder Reliability Agreement

HELPS		HURTS		ANSWER		SOURCE	
Coder One	Coder Two	Coder One	Coder Two	Coder One	Coder Two	Coder One	Coder Two
28%	34%	16%	12%	25%	37%	68%	57%

These results were not acceptable. During review of the coding it became apparent that although coding began with two coders, one proved too inexperienced in the technique and in interdisciplinary design. The decision was made to continue coding with the experienced coder only, Coder Two.

Review of coding results for Coder Two indicated that the majority of mismatches could be resolved by addressing a handful of issues. Issues included: looking at too many columns and reading too much in, clarifying expectations for future higher-level coding of behavior patterns such as collaboration, and explaining that confidentiality concerns limit my discussion of conflicts and disagreements as agreed upon with individual participants during their interviews. Initial review of big picture data by Coder Two summarized the concepts expressed by participants (Goal, Learning, etc.) and was so straightforward that no further review of big picture data was necessary in Phase 1 Round 2.

Intercoder reliability agreement percentages for Phase 1 Round Two, a negotiated resolution round, were acceptable as shown in Table 7.

Table 7. Phase 1 Round 2 Intercoder Reliability Agreement

Coder Two			
HELPS	HURTS	ANSWER	SOURCE
98%	96%	98%	100%

3.12.3 Intercoder Reliability Phase 2

Phase 2 Round 1 reviewed coding of questions and question basis. Intercoder reliability agreement percentages for Phase 2 Round 1, independent coding only, are in Table 8.

Table 8. Phase 2 Round 1 Intercoder Reliability Agreement

Coder Two	
QUESTIONS	BASIS FOR QUESTIONS
54%	37%

These results were not acceptable. Review of coding results for Coder Two indicated that the majority of mismatches could be resolved by addressing a handful of issues: looking at too many columns and reading too much in, clarification on several new codes, and attention to the full scope of item-specific responses.

Intercoder reliability agreement percentages for Phase 2 Round Two, a negotiated resolution round, were acceptable as shown in Table 9.

Table 9. Phase 2 Round 2 Intercoder Reliability Agreement

Coder 2	
QUESTIONS	BASIS FOR QUESTIONS
94%	98%

Reaching an acceptable level of agreement in two rounds reflects the coding expertise of Coder 2, who had strong design background in several disciplines. Using the lowest percentage of agreement gave a conservative overall intercoder reliability agreement of 94% for the study, well above the minimum expected agreement of 90%. We agreed to disagree on the remaining items. This concluded intercoder reliability coding.

After intercoder reliability was determined to be acceptable, the researcher completed coding for steps and four additional interviews. Sense-Making data analysis was begun and is summarized in the following section.

3.13 Sense-Making Data Analysis

This section summarizes the Sense-Making data analysis approach.

Basic descriptive statistics on demographic data consisting of age range, ethnic background, experience level, years as instructional designer, and gender were analyzed to provide insight on the range of participants. Due to the small size of the sample, to maintain confidentiality no data on the associated educational institutions was provided other than a general mention of size and geographical region. Participant ages were reported as age ranges.

Research objectives and the overarching goal of the study were addressed as follows:

RO1: To explore questions faculty ask during early conceptual instructional design.

Coded Question data was reviewed to explore the questions asked by faculty during their early conceptual instructional design experiences using semi-inductive content analysis. The combination of timeline interviews and inductive content analysis has been shown to be an effective means of collecting and interpreting evidence of cognitive processes without compromising the original expressions of the user (Schamber, 2000). Results from the 5 W's and an H coding, emergent data coding, and a frequency analysis were used to address RO1 along with narrative examples.

RO2: To identify uses that faculty associate with the questions they ask during their conceptual instructional design experience.

The coded question context data was reviewed to address RO2. Results from the 5 W's and an H coding, emergent data coding, and a frequency analysis were used to address RO2, along with narrative examples.

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

Patterns of behavior were identified through typical approaches to deductive and semi-inductive content analysis of sense-making data for question, question context, and big picture data. First, similar data was grouped and examined for emergent patterns using semi-inductive content analysis. Then deductive content analysis was used to identify possible patterns from literature or the researcher's experience. As data is exploratory and only covers a small portion of the overall instructional design experience, care was taken with respect to overlaying design models on data that does not reflect the entire design experience. Often there was little or no proof of successful design at the time that data was collected.

RO4: To explore what faculty feel is important about question-asking during instructional design.

Big picture data was reviewed to address RO4. While this data was less reliable than other data, it provided rich descriptions.

Overarching Goal of the Study: To provide a basis for future research on interventions to aid designers from all disciplines with question-asking during design.

An ad-hoc design mapping analysis was used to explore transferability by comparing study data (questions and question context) with questions asked in other design domains. Refer to section 3.7 for details.

3.13.1 Data Analysis Software

MAXQDAPlus11 software was used for qualitative data analysis in conjunction with Excel. MAXQDA permits coding of data similarly to how I previously coded data in Excel with the addition of many useful features, including: color and emoticon coding; coding memos, organizational and visualization tools; an intercoder agreement comparison feature; frequency count tools; data export for quantitative analysis; and vocabulary analysis. MAXQDAPlus11 was helpful for working with directly entered data, but there was a major flaw in the current version. A primary feature of MAXQDA is that raw and coded data can be imported directly from Excel. Unfortunately, an unadvertised bug resulted in Excel import failures for textual data on some systems and licensing restricts moving MAXQDAPlus between computers (Windows reinstall needed to reinstall MAXQDA). A fix was not yet available. Files were eventually imported with assistance from MAXQDA support, but there was no easy workaround for this time-consuming problem. Importing Excel files with substantial text content, especially design mapping files, required extensive document reformatting and stripping to plain text. Then extensive setup was necessary before coding and analysis could begin. This was problematic when working with multiple coders and design mappers using several versions of Excel and Word, in addition to collecting, coding and analyzing data in parallel. Extensive reformatting greatly increased the potential for unintentional changes to the data. As a result, most data analysis was done in Excel.

Several other visualization tools were tried, including QDA Miner, Inspiration, InspireData, QlikSense, and Wordle.com. Wordle.com was the only one with capability to do quick and flexible word frequency visualization. Wordle.com was used for word frequency visualization for Sense-Making data.

This concludes the methodology chapter. Chapter 4 discusses the study results.

CHAPTER 4. RESULTS

"Being persistent beyond belief goes a long way."

- A participant describing the designing experience.

4.1 Introduction

The findings of this study contribute to the four research objectives:

RO1: To explore questions faculty ask during early conceptual instructional design.

RO2: To identify uses that faculty associate with the questions they ask during their conceptual instructional design experience (Example: Did it help or hurt?).

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

RO4: To explore what faculty feel is important about question-asking during instructional design.

This section begins by discussing the timeline interview experience. Then initial findings for steps are discussed as necessary background for participants' instructional design experiences. Next, findings are presented for each research objective, including selected participant quotes. Selected quotes are taken directly from timeline interviews in participants' own words. Information in [brackets] is provided by the researcher for clarity. The quotes give a feel for the range of issues that faculty struggle with during early conceptual design. Sense-Making findings and design mapping results are then presented. Discussion of the implications of these findings for design support and professional development is provided in Chapter 5.

Note that the research objectives should not be interpreted too narrowly, as that could provide a negatively biased perspective on the range of experiences, questions and concerns, uses, and behaviors that faculty shared. The diversity and range of data in this study reflects the complexity of early conceptual instructional design, which is important to understand in order to identify means for improved design support. Data presented in this chapter consists of summaries and selected examples. Refer to Appendix M for the final codebook including sample responses.

4.2 The Timeline Interview Experience

The timeline interviews used in this study focused on the aspect of an instructional design situation that was new to participants. This generally required at least some explanation of surrounding design context, especially if the new aspect of the design was part of a larger instructional design effort. In several cases, participants were right in the middle of such a complex design situation that they really had to think about what to say. Participants tended to start discussion at a background point they were comfortable with and gradually worked forward until they felt they had communicated the requested design aspect and related context adequately. Long pauses to consider response wording were not unusual, especially for novices. One participant stated a need to give the background to assist with framing of corresponding questions. Researcher patience is required while participants think about what to say, but this was not a problem. Timeline interviews are intended to be a conversation rather than an interrogation, and good conversation tends to result when both researcher and participant are engaged.

This resulted in interviews that were often more of a conversation/story between the participant and interviewer. While this is not unusual for Sense-Making interviews, the complexity of participants' instructional design situations often resulted in lengthy interviews across a wide range of design-related topics and contexts.

As an example, one interview involved multiple intertwined new aspects of an extremely complex situation that the designer had not previously tried to explain as a whole. The interview was broken into three separate sessions on different days for a total of seven hours and 15 minutes. Five and a half hours of that time was the actual data collection interview, with the remaining time divided into researcher requests for clarification of specific data and, primarily, discussion of the dissertation research. This case was an anomaly due to the complexity of the design situation and the difficulty of explanation on the part of the participant to break down a lengthy design project at a meta-level in order to answer the research questions (English as a second language may also have contributed). The participant expressed during the later portion of the interview that it was helpful to him to think about his project at the meta level in ways he had not done previously. This interview was an anomaly, but was very useful.

Another participant expressed similar benefit from the interview:

"It's a sensitive situation. I don't want to impose - need to show benefit. I've got to find a way to make [teachers needed to host student teachers] feel that they have a positive stake in the outcome. It is asking them to take a risk, committing to something at the beginning of the semester, to something they've never done before. If the students become impossible to work with or are uncooperative then it could have a negative impact. <u>As you - you're actually helping me think through all of this.</u> I think this is actually my biggest problem - if I can figure out a way of getting these teachers enthusiastic and feeling that this will benefit them, everything else will fall into place. If I don't, the whole thing could turn around."

Nine faculty requested longer interviews to discuss complex design experiences. All participants wanted to talk about the study. Interview and post-interview discussion durations are summarized as:

Interview duration:

- Low: 28 minutes
- High: 7 hours and 15 minutes (anomaly)
- Average: 54 minutes (excluding anomaly)

Post-interview discussion on the study and benefits of question asking:

- Low: Two minutes (corresponded with the 28 minute interview duration for a 30 minute total timeframe)
- High: One hour and 45 minutes (anomaly, but several participants had discussions of an hour or more)
- Average: 20 minutes

Refer to section 3.8.1 for additional information on the timeline interview.

Faculty showed interest and dedication during the interview and discussion process. Selected examples of faculty responses are provided in the following sections and are discussed further in Chapter 5.

4.3 Findings for Steps

This section discusses findings for steps with the exception of identified patterns of behavior for steps, which are covered in section 4.6.

4.3.1 Background for Steps and Step Context

Steps reflect actions taken by users. An understanding of steps is important because steps tie together questions and question context through complex design.

At the coding level, the only commonality observed across all participants' instructional design experiences for steps was that each involved *Coping with Newness*. The topic of the interviews was to discuss an instructional design experience containing something that was new to the participant, so it was not a surprise that *Coping with Newness* was a commonality. It was a surprise that no other commonalities were found. This was quite different from, for example, Sense-Making research on online purchasing, in which participants shared multiple steps and sequences such as browsing, researching and selecting (Nilan & Mundkur, 2007). The next section discusses step context.

4.3.1.1 Step Context

Step context was established at the beginning of the timeline interview by asking participants about:

- The subject matter of their instructional design experience
- Whether their design was for a classroom or online course
- Whether the course was cross-disciplinary in nature
- What previous experience the participant had with the subject matter

Results for step context were:

Subject Matter: Recruitment succeeded in finding participants from varying academic disciplines, with 17 subject matter areas across 18 participants. Refer to Table 3.

Classroom or Online Course: All participants were performing instructional design for classroom courses (classroom, lab, and/or studio) with the exception of one course that was becoming a hybrid with a substantial new online component.

Is the Course Cross-Disciplinary in Nature: Issues related to cross-disciplinary instructional design were more numerous than anticipated. This was in part due to interviewing several faculty who were heavily involved in local workforce development programs.

A point of confusion was that it was often unclear whether a course was really interdisciplinary, cross-disciplinary, or multidisciplinary, and/or whether that determination was made by the participant due to the subject matter involved, student background, academic majors, or any combination thereof. As the intent was simply to identify questions/concerns associated with cross-disciplinary or related aspects of instructional design (such as interdisciplinary and multidisciplinary situations), and interview time was valuable, no effort was made to further investigate participant's reasons for their responses to this question. It was more important to identify associated questions/concerns.

Previous Experience with Subject Matter: Participants were asked to discuss a recent instructional design experience that contained something that was new to them. All participants discussed new (to them) aspects of instructional design, with prior experience ranging from none or tangential only to substantial experience with the course but little or no prior experience with the new aspect. Refer to Table 10.

Table 10. Participant Responses for Prior Experience with Subject Matter

Prior Experience with Subject Matter?
Industry only.
I taught different courses that are related to this course, but I had no experience with this course itself. Related computer controlled design, but I never put together a course like this.
Yes, but now want students more engaged online.
No.
Similar course at another school.
I've been teaching it for 10 years, but extensively revamped the course - a new approach.
None.
Substantial experience teaching the course, but public critiques of students teaching are new.
None.
This is the third time teaching the course, but I have two new topics (mass and energy balances) and a new text.
Not really. What's new to me is group presentations.
None with Turn It In.
With parts, others are new.
I enjoy it, but didn't have a lot of direct experience. I have the physics background and had worked through with professors from a different perspective. I read a lot, self-taught, took computer science courses, and have a predisposition toward these things. Also I attended conferences and trade shows.
I know how to do it but never tried to teach it. I had classes at my previous school and training here just before class started. This is my first time teaching.
Yes for teaching, but not for peer tutoring.
With Excel, but not with this new instructional approach.
Only tangentially from ties to mythology.

4.3.2 Findings for Steps

Steps focused on things that were new to participants, as illustrated in Table 11.

Table 11. Steps Taken during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
Something New	Enthusiasm, Working with Others, Content and Materials, Relevance, Planning, Pilot Testing the Design, How to Engage Students, Research, Information Needs, Technology, Assignments, Instructional Methods, Skills, Employable Outcomes, Student Feedback, Evaluation, Assessment, Learning, Curriculum, Novice/Expert Issues, Problems and Opportunities

Figure 10 shows the frequency of steps per data category. *Something New (Coping with Newness)* was by far the most frequent with approximately 26% of step data. Remaining categories had fewer than 10 instances each, with *How* and *References* most common.

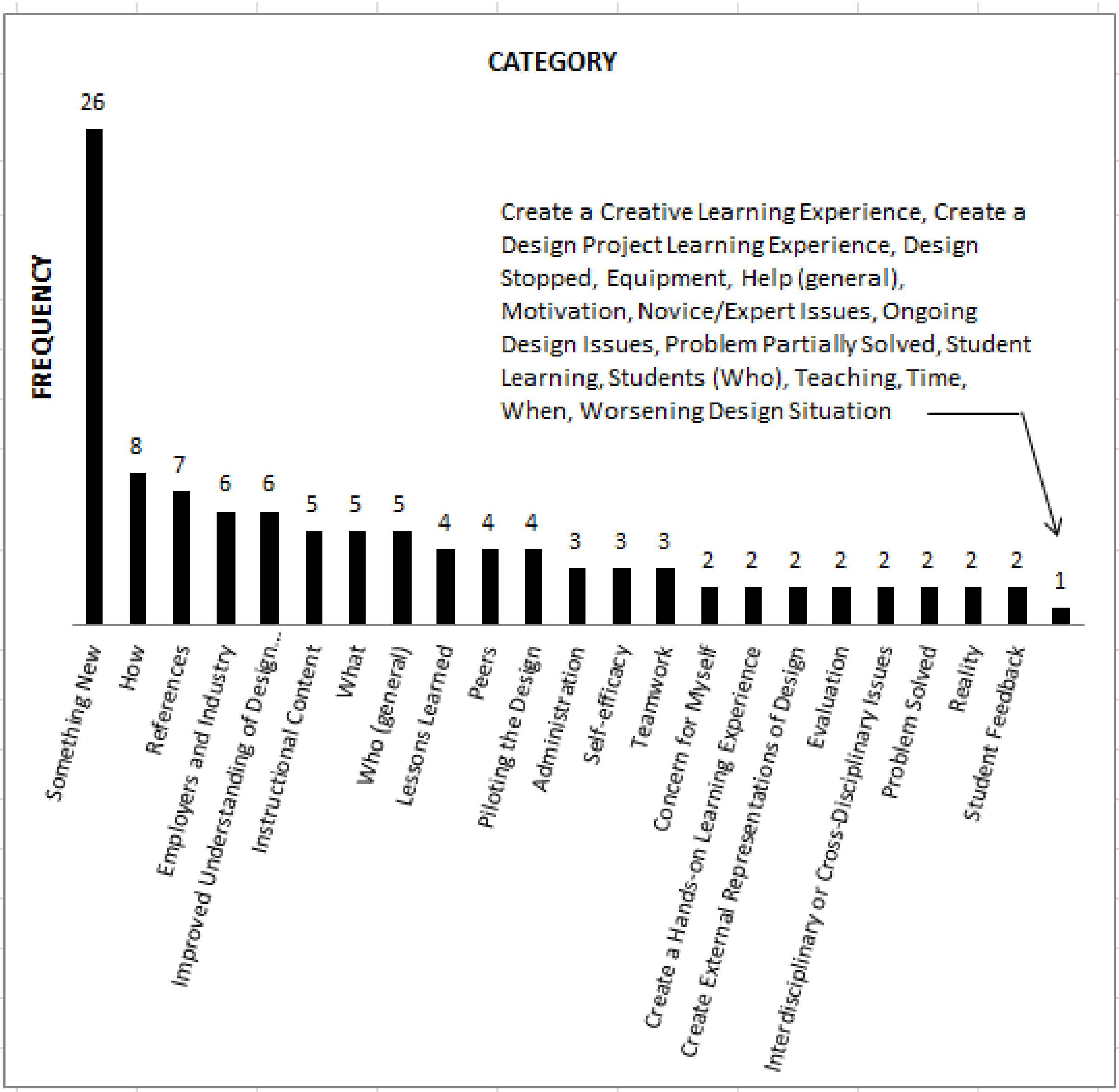


Figure 10. Step Frequencies per Data Category

The next section presents a few participant quotes to give a sense of the steps faculty shared while describing their instructional design experience.

4.3.2.1 Selected Participant Quotes for Steps

The selected quotes below are faculty descriptions of their steps during the early conceptual stage of their instructional design experience.

Something New (Newness): "Had to overhaul a cross-disciplinary, common core requirements course I'm not familiar with. Multimedia and programming. Common core courses have additional requirements and outcomes."

How: "Determined how it fit into the entire curriculum. (…) Until you've been through it once you're not very good at answering that question."

References: "I looked at counterpoint books that have five views of an issue. I wanted to have group presentations where students take sides on issues."

Motivation: "Excited to teach it [study of antibody responses]."

Teamwork: "Worked with program director on certification requirements and tests."

Equipment, but selection of technology rather than concerns: "Start thinking about appropriate technology. A. Teach in Flash (current) - old, useful for concepts. B. Processing multimedia language - visual. C. HTML, CSS, JS, Canvas - web program."

Creative and Design Projects: "Innovation. Realized I didn't want to do 20 case studies about advanced building systems (very large class). Instead, I want to do a historical survey of case studies and have students create technical drawings of their own design. Covers technical data, representation of systems, drawing and socioeconomics."

Teaching: "I did a brief presentation in class with the PowerPoint. I gave the students the PowerPoint slides and the tutorial."

4.4 Findings for Research Objective 1: Questions Asked

RO1: To explore questions faculty ask during early conceptual instructional design.

Background: Questioning is critical to design. A better understanding of questions asked by faculty during conceptual instructional design can help us find better ways to help faculty during designing. RO1 focused on eliciting data on the questions asked by faculty during their early conceptual instructional design experience.

This part of the interview process involved situating participants at the first step of their instructional design experience and having them list questions (or concerns) they had at that time. This process was repeated for each step in the participants' instructional conceptual design experience, resulting in a list of questions by steps.

Questions were initially grouped per Dervin's Five W's and an H: *How, What, When, Where, Why* and *Who*, an approach used since the development of the timeline interview technique (B. Dervin, et al., Editors, 2006). That may seem straightforward, but it's not necessarily so. For example, '*What*' is a fairly straightforward type of question, such as a participant wanting to know the general topics for a course, which can be answered readily with provision of a course description and syllabus. '*How*' questions can reflect a much wider range of issues – such as how several different technical fields can be interwoven in a hands-on student design project, and how to address concerns about students lacking math and writing skills. As the study progressed, emergent categories and additional pertinent Sense-Making analysis categories were added. Additional Sense-Making categories included *resources, verbing, situation, stops/barriers/constraints, goals, attitudes*, and *emotions* (B. Dervin, et al., Editors, 2006). Findings reported for questions and question context are presented in terms of specific data coding categories rather than the higher level Sense-Making data analysis categories. This maintains the level of detail needed to see the range of design issues encountered by participants. For details of data coding and analysis refer to Chapter 3.

4.4.1 Findings for Questions

Figure 11, a word frequency diagram based on participants' own words, shows clearly that the primary focus of faculty's questions and concerns overall involved students.

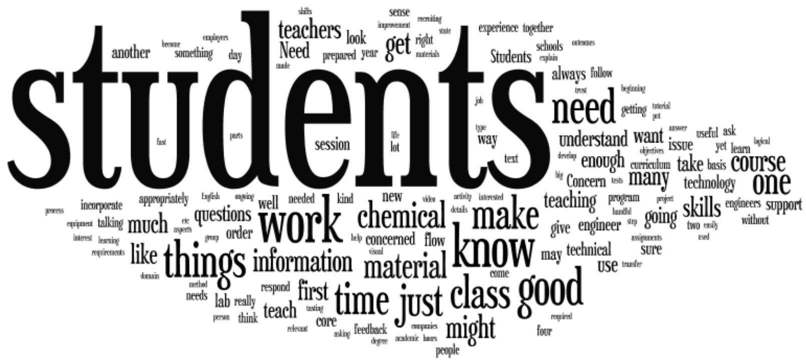


Figure 11. Word Frequencies – Participants Questions and Concerns

Questions faculty had were diverse, covered a substantial range of topics, and had several key areas of focus, as illustrated in Table 12. Examples of questions are provided in the following section.

Table 12. Questions Asked during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
How to Do Something What is Something? Concern for Students Concern for Self	Retention, Motivation, Relevance, Special Concerns of International Graduate Student Instructors, Student Background, Appropriate Materials, Sequencing, Administration, Expectations, Evaluation, Resources, Time, Cross-Disciplinary Development, Employers/Economy Driven Concerns, Student Diversity

Figure 12 illustrates the frequency of questions per data category. Question categories of *How* and *What* were most common, accounting for approximately 57% of the question data. *Concern for Students* and *Concern for Self* were the next most frequent categories, accounting for approximately 26% of the question data. Concerns about *Instructional Content* (accuracy, appropriateness, etc.) and issues of *Self-efficacy* were next, accounting for approximately 15% of the question data. *Self efficacy* issues include positive or negative emotions associated with participants' belief in their own ability to meet instructional design goals or personal goals associated with their instructional design situation. Remaining categories had fewer than 10 instances each.

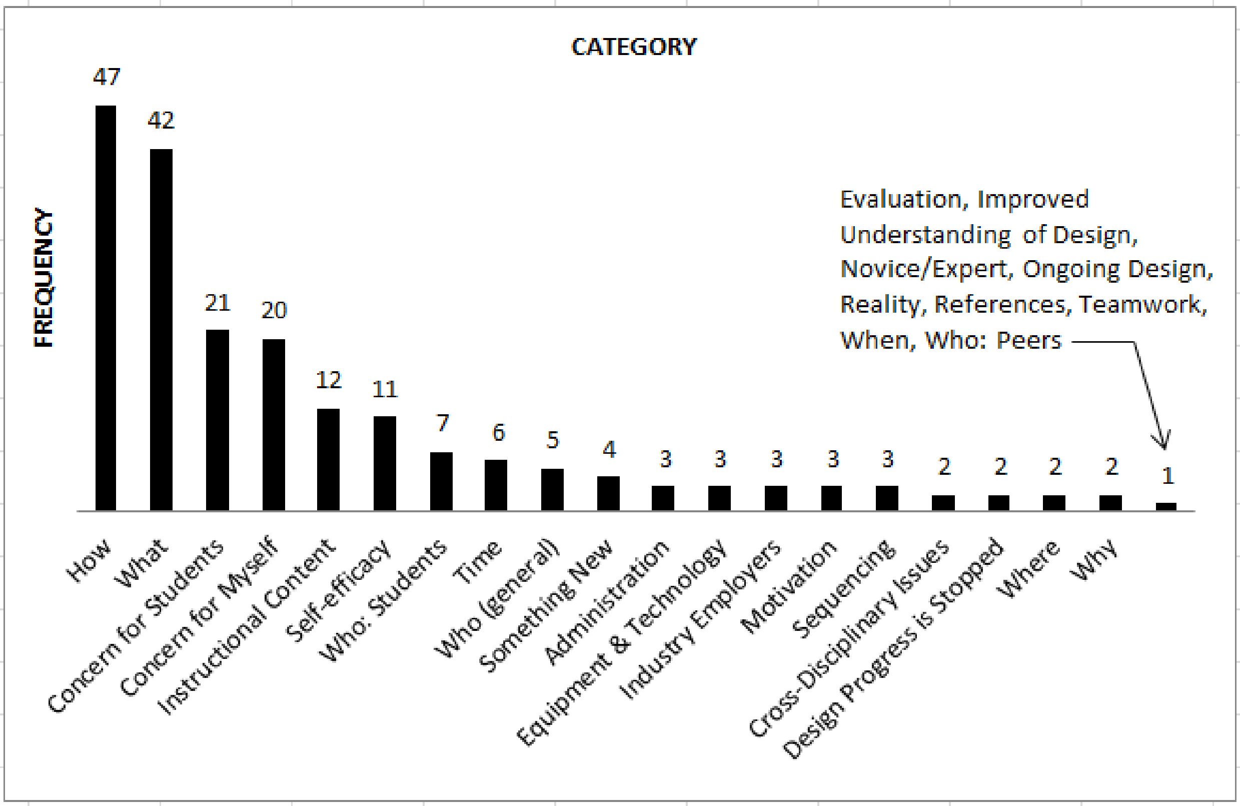


Figure 12. Question Frequencies per Data Category

The next section presents selected participant quotes for questions.

4.4.1.1 Selected Participant Quotes for Questions

The selected quotes are questions and concerns expressed by faculty about their instructional design situation, taken directly from timeline interviews in participants' own words. Only a handful of the 157 questions elicited in the study are presented here. These quotes give a feel for the range of issues with which faculty struggle during early conceptual instructional design. Discussion of question data with respect to Sense-Making is in section 4.8. Discussion of the implications of question data for design support and professional development is in Chapter 5.

How: "How to incorporate areas - materials, manufacturing, programming, etc."

What: "What's World Literature [course number]?"

Concern for Students: "I'm trying to teach them what a chemical engineer is. Most students who are proposing to become chemical engineers don't know what a chemical engineer is. How do I teach them what chemical engineering is and what they might be doing one day? How do I show them that this material we're learning is pretty much the basis of every course they take in the department? Have them see how everything fits in - not wait until the senior year. Need to see this to avoid frustration and maybe changing majors. How to get students to think forward to life as chemical engineers? Summary: How effective am I going to be at doing this and how to make this relevant to life as a chemical engineer and how to make them think forward to the generic activities a chemical engineer does and also what they might be doing themselves with it one day. I'm not sure."

Concern for Self: "I'm an international student, concerned about my English language skills. Students might not understand me" and ***Self-Efficacy***: "I get nervous when I'm in front of a crowd. Am I speaking too fast?"

Sequence: "How to develop a logical flow for the class. A lot of people just follow along with the textbook in the order that it's written down. I would argue that only about half the time is that actually the most logical order of presentation for the material such that students can tie things together, the right things follow upon the right things. I was concerned about following the text order - should I follow the text order? Will it flow well?"

Interdisciplinary Design: "How to incorporate interdisciplinary lesson development?"

Who: "Who will help me and answer my questions?" and ***Where:*** "Where can I learn this?" [Expressed by both novice and more experienced faculty].

Employers: "Business feedback is important. Each company wants a degree program to meet their needs."

Something New (Newness): "Want to spread talent around, keep same cohorts, work together. This is not usual for many degree programs."

4.5 Findings for Research Objective 2: Uses of Questions

RO2: To identify uses that faculty associate with the questions they ask during their conceptual instructional design experience (Example: Did it help or hurt?).

Background: Uses include Helps, Hurts, How an Answer Helped (Answer) and Source of Question (Source) data. Dervin's Sense-Making data analysis category of Why, which is the Basis for Question data in this study, also supports RO2.

Uses are important as they reflect what was relevant to the participant and provide additional understanding of question context and what helped or hindered the participant (B. Dervin, et al., Editors, 2006). This information is useful for identifying faculty needs during conceptual instructional design and for development of best practices.

This part of the interview process involved situating participants at each of the questions they had during their instructional design experience and having them list any uses associated with that question. This provided detailed question context. Uses were analyzed for both Sense-Making and emergent data categories.

The next five sections present findings for each type of uses and provides selected participant quotes. The selected quotes are uses shared by faculty about their instructional design situation, taken directly from timeline interviews in participants' own words. The quotes provide insight on uses that faculty perceive for their questions.

4.5.1 Findings for Basis for Questions

Findings for the Basis for Question are primarily focused on the self (*Myself*) and faculty's own experience, providing information on the relevance of the question to the participant. Other responses ranged across many categories and design topics. Refer to Table 13 for an outline of key foci and topic diversity. Examples of basis for questions responses are provided in the following section.

Table 13. Basis for Questions Asked during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
Myself What Students (Who) Concern for Students Reality (barriers, attitudes, emotions, constraints)	Needing to Know How to Do or Evaluate Something, References, Locating Resources, Equipment Problems, Lack of Knowledge or Skills, Applicability of Past Education, Curiosity, Student Difficulties in the Classroom, Student Feedback

Figure 13 below illustrates the frequency of basis for questions responses per data category. The basis for question coding category of *Myself* (own experiences) was most common, accounting for approximately 25% of the basis for question data. The categories of *Students (Who), Concern for Students, Concern for Self, What* and *Reality* were the next most frequent categories, together accounting for approximately 46% of the basis for question data. The remaining categories had less than 10 instances each.

The next section presents selected participant quotes for the basis of questions.

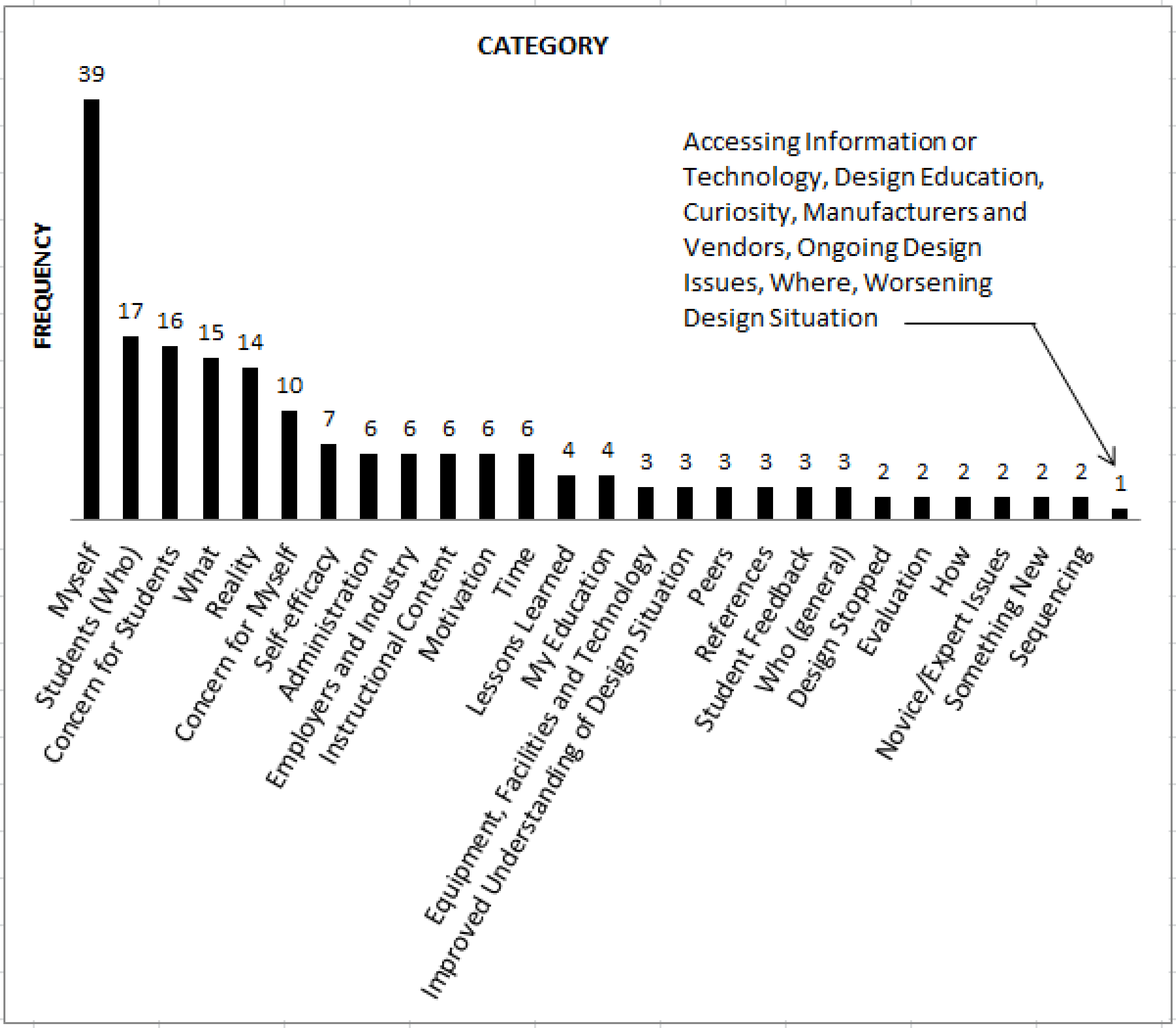


Figure 13. Basis for Questions - Frequencies per Data Category

4.5.1.1 Participant Quotes for Basis for Question

Participant anxiety or concern about the design situation was often apparent during this portion of the data collection interview, as can be seen in the majority of these quotes.

Myself: "Previous student groups write as if things are perfect."

What: "To determine what jobs we need our students to be able to fill."

Students (Who): "Some students are older and may have education I'm not aware of."

Reality: "The schedule for the course was moving me along faster than anticipated," and "I wanted students to have a genuine engineering experience, making many things from fundamental principles, from scratch as much as possible. I didn't want them to have to go out and buy components and put them together."

Who: "I know I'm not technical. I needed somebody to show me this and answer questions."

Equipment: "I have to use resources effectively without a lot of prior planning. How to approach that? Part of why is technical difficulties with the computers that slow us down. I need time available to help students but also to fix technical issues."

Self-Efficacy: "If I knew more then I could explain better and have more confidence. I don't have advanced skills," and ***Content***: "Students had problems in lab. The instructions in the tutorial didn't work."

Student Feedback: "Some students just blatantly expressed that lessons are 'stupid'."

Education: "I attended a lecture where students hung assignments on the wall and critiqued art for hours. I was struck by the public nature of the critiques. Until then I viewed feedback as one-to-one and private."

References: "Bloom's taxonomy - am I just telling them what to do or helping them discover what to do?"

Concern for Students: "I was concerned that students might be too nice or resent the public critiques. I want the students to get food for thought. Anxiety was a concern. This cohort is close. There could be out of class consequences socially."

4.5.2 Findings for Helps

Helps are useful for identifying design activities, associated resources, etc. that moved the design forward by aiding the user, and can provide input for process improvement or insight for ways to aid designers.

Helps findings focused primarily on *References* and had two of the most intriguing responses of the study related to *Motivation*. Other responses ranged across many categories and design topics. Refer to Table 14 for an outline of key foci and topic diversity. Examples of helps are provided in the following section.

Table 14. Helps Identified during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
References Peers Motivation	Motivation of Self and Students, Engaging Students, Turning Problems into Opportunities, Peer Networking, Identifying and Investigating Options, Learning, Partial Solutions, Time Management, Piloting the Design, Working with Employers, and Novice/Expert Issues

Figure 14 below illustrates the frequency of basis for questions responses per data category. The basis for question category shows a more gradual slope from most to least frequent responses than was seen for questions or basis for questions. *References, Peers*, and *Motivation* were the most common responses, together accounting for approximately 35% of the Helps data. The categories of *Self Efficacy, Student Feedback, What*, and *Improved Understanding of Design Situation* were the next most frequent categories, together accounting for approximately 30% of the Helps data. The remaining categories had less than 10 instances each.

The next section presents selected participant quotes to give a sense of what faculty felt helped them during their instructional design experience when they had questions or concerns.

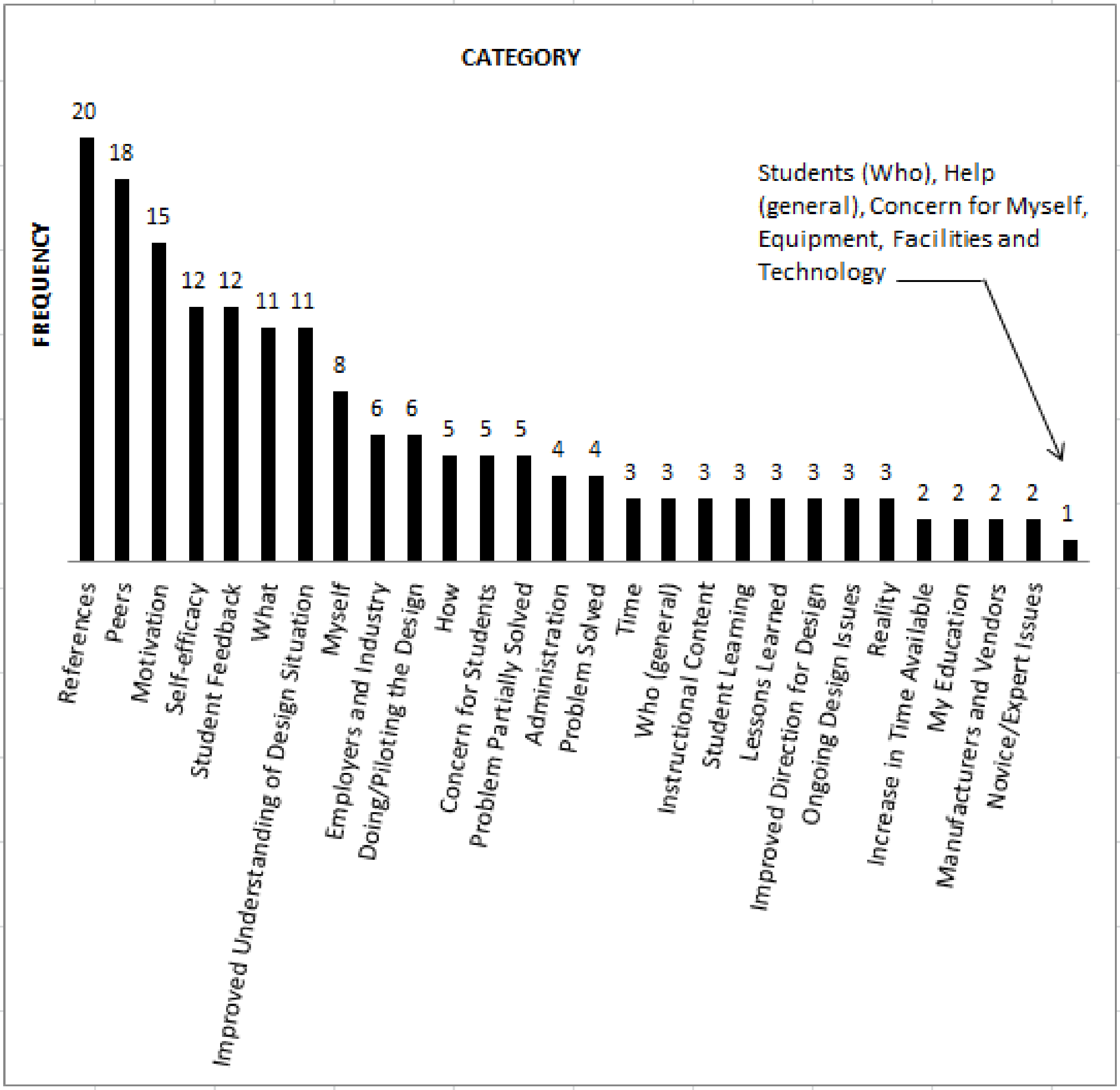


Figure 14. Helps - Frequencies per Data Category

4.5.2.1 Participant Quotes for Helps

Helps data tended to reflect interesting ideas and lessons learned as well as a wide range of faculty needs and problems addressed. An interesting response was hope. Hope may not often be thought of as a use, but hope was an important source of motivation for several participants. Examples include hope for student success and evidence that a new instructional design approach may be working.

Two detailed examples of motivational techniques and eleven other examples are presented to give a sense of the variety of helps that faculty see for their questions.

Motivation - The Cake Story: "The approach I was taking was twofold. I tried to identify and use the energy I got out of [the challenge of learning something both difficult and very interesting] toward learning basic things I can do and transmitting back things [to students]. An example (the cake story) - this is sort of my modus operandi. I never had any experience cooking. I never had any training on cooking. When I was a post doc I bought some fancy cookbook. It had all kinds of recipes. And so I wanted to make a cake for a friends' birthday (...) Instead of looking through the cookbook and finding a simple cake to make because I'd never done any baking before, I looked for the most difficult cake that there was. It was a Cassata Siciliana cake. It had several sections to it. I assembled ingredients, I bought implements that I needed, and I proceeded to make the most difficult cake that there was. And I succeeded. I had to improvise to some extent. The cake was not quite brick-shaped as it was supposed to be. I used to do some painting, so I used a palette knife to kind of sculpt the frosting to make it. It came out ok! And I made that same cake once again maybe five to six years later. That's it. I have never baked anything before or since. When I'm encountering something new I try to use it - I can find something exciting that will get me going on it. Because I've found if I do the usual way where I read chapter after chapter (...) and then figure things out I somehow am not very good at it. I have to do something that will mean something to me and is not something other people can easily do. I don't always succeed in finding that groove, but I'm the happiest if I can do that (laughter). There's still a lot more I need to learn to teach, but I feel that I need to find things that will excite me because I think if I am interested the students can sense it and I want them to acquire that taste. Because you always want to learn new things and you don't always want somebody else to tell you exactly how to do things."

Motivation - Finding the Art in Technology: "One thing I kind of get a kick out of is, I think partly because when I was growing up I wanted to be an artist (...) So with technology I like to see if there is some fun, artistic thing you can do because I latch onto that, that gives me motivation to learn. And I try to bring that out for the students as well of course I think that technology has its own utilitarian aspect to it which is a major part of it, but as human beings we don't have to strictly live on utilitarian - as human beings we ought to be able to explore. If we don't do it ourselves we could at least be able to appreciate somebody else's creation."

Improved Understanding of the Design Situation: "My understanding wasn't correct. It's not an automatic process [TurnItIn.com]. I need to find out how to set it up."

Improved Understanding of the Design Situation: "Asking questions improved my understanding."

Student Feedback: "Looked at last years' student reviews. I thought students wouldn't like one thing, but reviews liked it. Surprise! [Working with journal articles]."

Lessons Learned: "In course planning I always figure there's always a way of turning a problem into an opportunity. And there's no sense in wringing my hands and getting paralyzed by all the problems I'm buying into. If you look for a way of turning a problem into a strength or an opportunity you can usually find it."

Student Learning: "Students continue to learn and inquire, sense shortcomings and address them or ask for help rather than hiding things."

References: "Go on the Internet and find reliable sites."

Partial Solution [New online approach]: "Some students did access it and shared with me the information that they had clearly gotten from the instructional materials and the online resources. A very set number, but it was clear. Could see it could work - light at the end of the tunnel."

Doing (Piloting) the Design: "Working on pilot project to understand pitfalls and what's too difficult. In the early stage of the course it was up and down. We went too far in detail and then we scaled back, and that was too simple - until we found the balance."

Concern for Students: "I was hoping if I was successful in this it would help me keep students from getting frustrated when they didn't see the path forward, and leaving the program."

Who: There must be people on campus [for help, from a senior faculty member]."

Peer: "Needed language [to encourage students to participate in public critiques], so I borrowed prompts from colleagues and improved my skills."

Novice/Expert Issues: "I was working the problems from the perspective of someone with a lot more background, and frankly a lot more math and problem solving skills than them, but I was still doing it with a fresh eye and looking for places where I could make mistakes."

4.5.3 Findings for Hurts

Hurts often communicate very specific problems that participants have struggled with. Hurts are important as potential issues to be addressed through instructional design support and/or professional development to assist faculty during design.

Hurts focused primarily on concern for self and concern for students. Other responses ranged across many categories and design topics. Some hurts were similar to responses for other categories. Refer to Table 15 for an outline of key foci and topic diversity. Examples of hurts are provided in the following section.

Table 15. Hurts Identified during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
Concern for Students Concern for Myself Self-efficacy What	In-class Critiques, Poor Textbooks, Under or Overestimating Student Capabilities, Lab Equipment Sharing, Outdated Perceptions of potential students, parents, and high school staff, Assessment, Student Group Communications, Prep Work for Online Content, Design Fixation, Budget and Facility Issues, Failed Instructional Design, Fear of Asking Questions, Fear of Appearing Stupid, Fear of Problems in the Classroom, Fear of Poor Student Evaluations, Concerns about Novice Students and Barriers between Experts and Novices.

Figure 15 below illustrates the frequency of hurts per data category. Concern for *Students* and *Concern for Self* were the most common responses, together accounting for approximately 45% of the hurts data. The categories of *Self Efficacy* and *What* were the next most frequent categories, together accounting for approximately 23% of the helps data. The remaining categories had less than 10 instances each.

The next section presents selected participant quotes to illustrate what faculty felt hurt or hindered them during their instructional design experience at the times when they had questions or concerns.

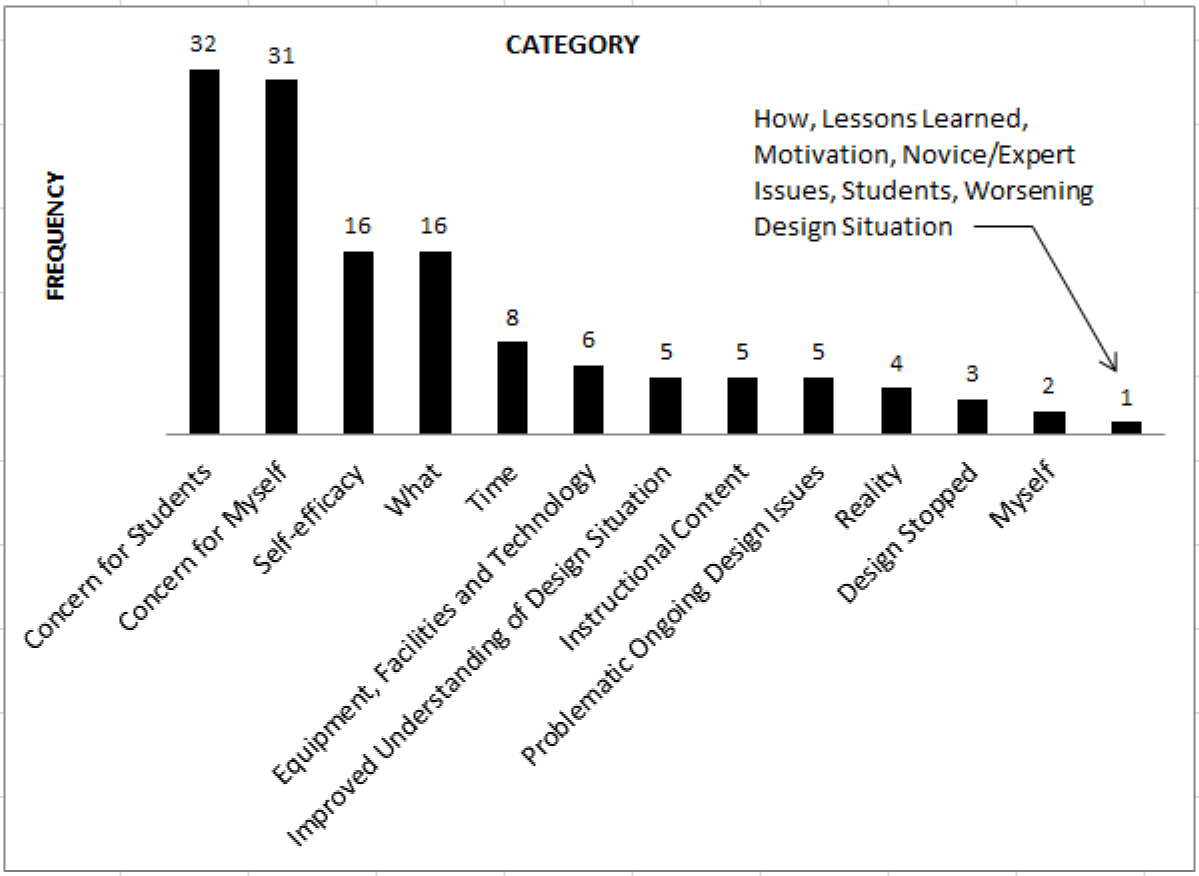


Figure 15. Hurts - Frequencies per Data Category

4.5.3.1 Participant Quotes for Hurts

Hurts data reflects a broad range of complex and sometimes sensitive issues.

Concern for Self: "If critiques were too negative students might complain, which could impact my teaching evaluation, and potentially escalate to the Dean. The critique process exposes a vulnerability. Teachers are expected to know all this, but we're constantly learning."

Concern for Students: "Giving up too early on a student. Giving materials that are too advanced too soon."

Concern about Equipment: "One piece of equipment interfaced with software on a computer. Problems with people changing each other's programs."

Concern about Content: "Not getting good animations. Need to re-screen and watch for bad info. Terminology confusion and typos in text made it harder to do what I needed to do."

Ongoing Concerns: "Parents and high school staff may have an outdated perception of the manufacturing environment as menial and not high tech." and "There was this situation where, for instance, I see the student does the work but doesn't do a good job on the journals. That was a problem area. How to assess that situation." and "It did become a problem, students didn't communicate, and I didn't know quite how to solve it. … if the two groups didn't communicate properly the project wouldn't come to fruition and it would cause frustration among the groups."

What: "Answers could limit what I could do for instruction."

Reality: "Work required to prepare instructional material to be accessed online, which can be quite sizeable."

Design Stop: "Analysis paralysis. Need answers, opinions have pluses and minuses," and [Lack of facilities] "Resulted in an 18 month holdup, highly sensitive situation."

Time: "The time for prep was short. Teaching started right after my training!"

Worsening Design Situation: "It's potentially not useful."

Self-Efficacy: "Seeing a glimmer of evidence and from that thinking it's working!" and "Fear of what colleagues would think if questions sounded stupid," and "The experience of failure kept me from enjoying teaching in the beginning. I'm feeling a little better now. It hurt my feelings that I needed to improve more. Feel down because I'm not good enough."

Novice/Expert Concerns: "I would say students I work with, a good fraction, maybe at least a third if not more, are people who have never imagined themselves to be in a technical field, but they got into it out of necessity or out of realization that maybe this is something they might become good at, but they had not thought so when they were starting out after high school. With these people sometimes there are other difficulties that a person who is expert in the technical field is used to and sometimes does not relate [blocks against mathematics as an example]. There are psychological barriers or issues and we need to be aware of that and basically help people overcome those."

4.5.4 Findings for How an Answer Helped

How an answer helped is how the participant thinks the answer to a question helped with the instructional design situation, an expression of relevance. Refer to Table 16 for an outline of key foci and topic diversity. Examples of how an answer helped are provided in the following section.

Table 16. How an Answer Helped during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
Ongoing Design Issues Problem Solved Self-efficacy What	Partial Answers, Pilot Testing Instructional Design Live in the Classroom, Validating Design Direction, Student Feedback on New Instructional Approaches, Learning How to Do Things, Working with Experts, Incorporating Administrative Requirements, Employer Needs, Past Experience as a Primary Resource.

Figure 16 below illustrates the frequency of hurts per data category. Ongoing design issues were by far the most common response, accounting for approximately 36% of the How an Answer Helped data. The categories of Problem Solved, Self Efficacy, What, and Improved Understanding of the Design Situation were the next most frequent categories, together accounting for approximately 47% of the How an Answer Helped data. The remaining categories had less than 10 instances each.

The next section presents selected participant quotes to illustrate how faculty felt that answers to their questions helped them during their instructional design experience.

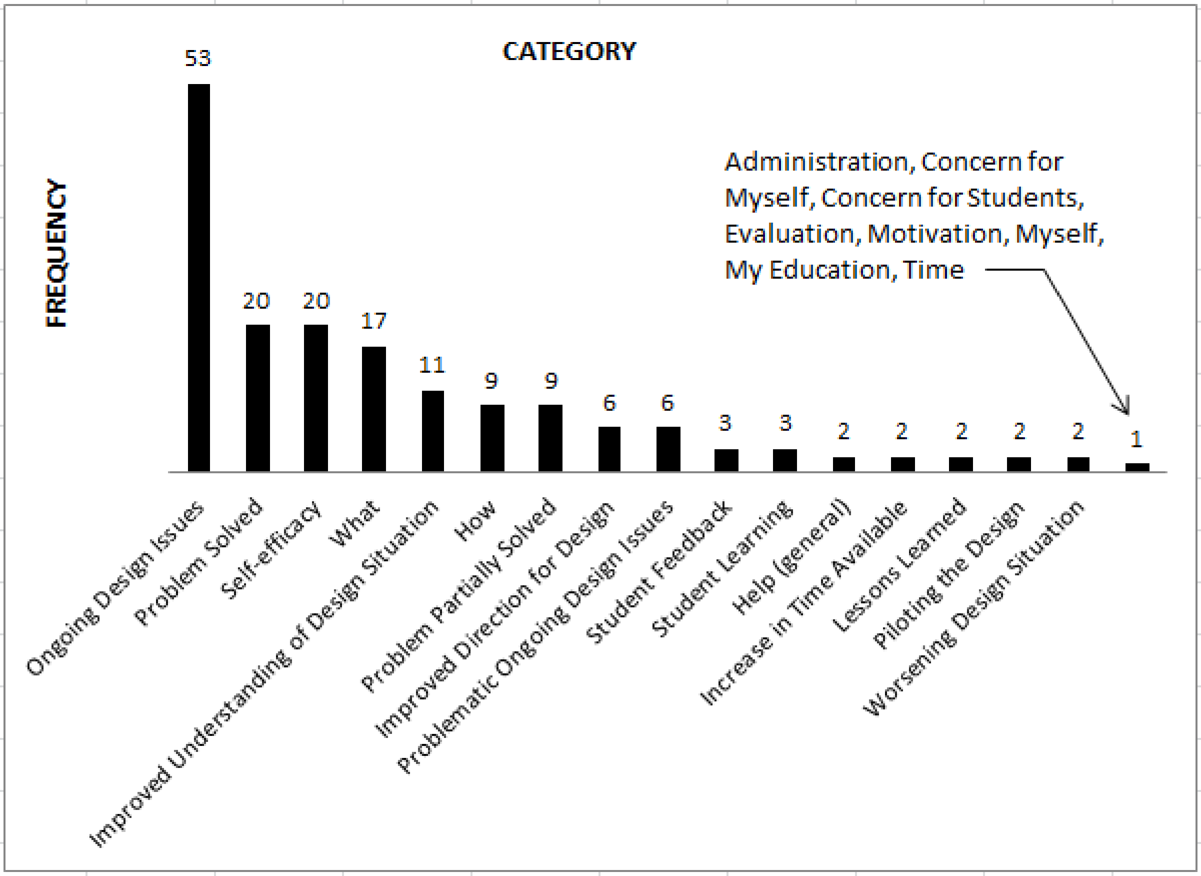


Figure 16. How an Answer Helped - Frequencies per Data Category

4.5.4.1 Participant Quotes for How an Answer Helped

How an Answer Helped data was strongly focused on dealing with ongoing design issues, as well as a wide range of faculty needs and problems.

Ongoing Design Issues: "Partial answer. I still think there are some improvements to be made."

Problem Solved: "Able to offer tuition solutions to potential candidates."

Doing (Piloting) the Design: "Experience with the project helped me to reformulate the level of detail and redesign the course."

Student Feedback: "Feedback from students helped. I had initial meetings with the students to discuss the critique process, and they wanted to keep going in spite of some complaints."

Self-efficacy: "Reassured me and helped a lot to develop useful, real life work for students."

What: "I know the exact type of student needed versus not needed for the employers."

Self as a Resource: "Because of past experience I had a sense of what would be appropriate."

Improved Understanding of the Design Situation: "I don't know if I can classify students as a whole in terms of categories, but I would say that there was a sizeable number who while they had evidence to suggest that they had a strong familiarity and usage of access to the Internet and to technology, were not really prone to use it in a classroom situation. It was more for entertainment. This is not an uncommon development, right? And I think there are those who may very well resist it because they feel this is an art class - I'm here to come in and do the work as we do within the confines of our time that we're together, and that's it."

Improved Understanding of the Design Situation: "I began to understand why…faculty members don't undertake some massive overhaul or new territory, because all of a sudden you could find yourself to be somewhat naked, so to speak, because you don't have those decades of experience to fall back upon in an area. I think as faculty members, most of us want to be correct 100% and we don't want to be 'vulnerable' in front of students."

Concern for Self: "Self-preservation. Need to know if this will be financially sustainable."

4.5.5 Findings for the Source of Question

Sources help participants to bridge gaps (B. Dervin, et al., Editors, 2006). Findings for the Source of Question are primarily focused on *Myself* (own experience), as shown in the word frequency diagram in Figure 17.

Figure 17. Word Frequency Diagram for Source of Question Data

Source of Question responses of *Myself* account for approximately 66% of the Source of Question data. Other responses ranged across many categories and design topics at much lower frequencies. Refer to Table 17. Examples of sources of questions are provided in the following section.

Table 17. Source of Question during Early Conceptual Instructional Design

Key Foci (Coding Categories)	Diversity of Topics
Myself (Self)	Past Experience with Student Errors, Past Education, Unexpected Complexity and Ongoing Learning, References (National Public Radio, books, dissertations, articles, and the literature), Encouraging Lifelong Learning in Students, Students as Concerns and Allies.

Figure 18 illustrates the frequency of source of question responses per data category, followed by participant quotes.

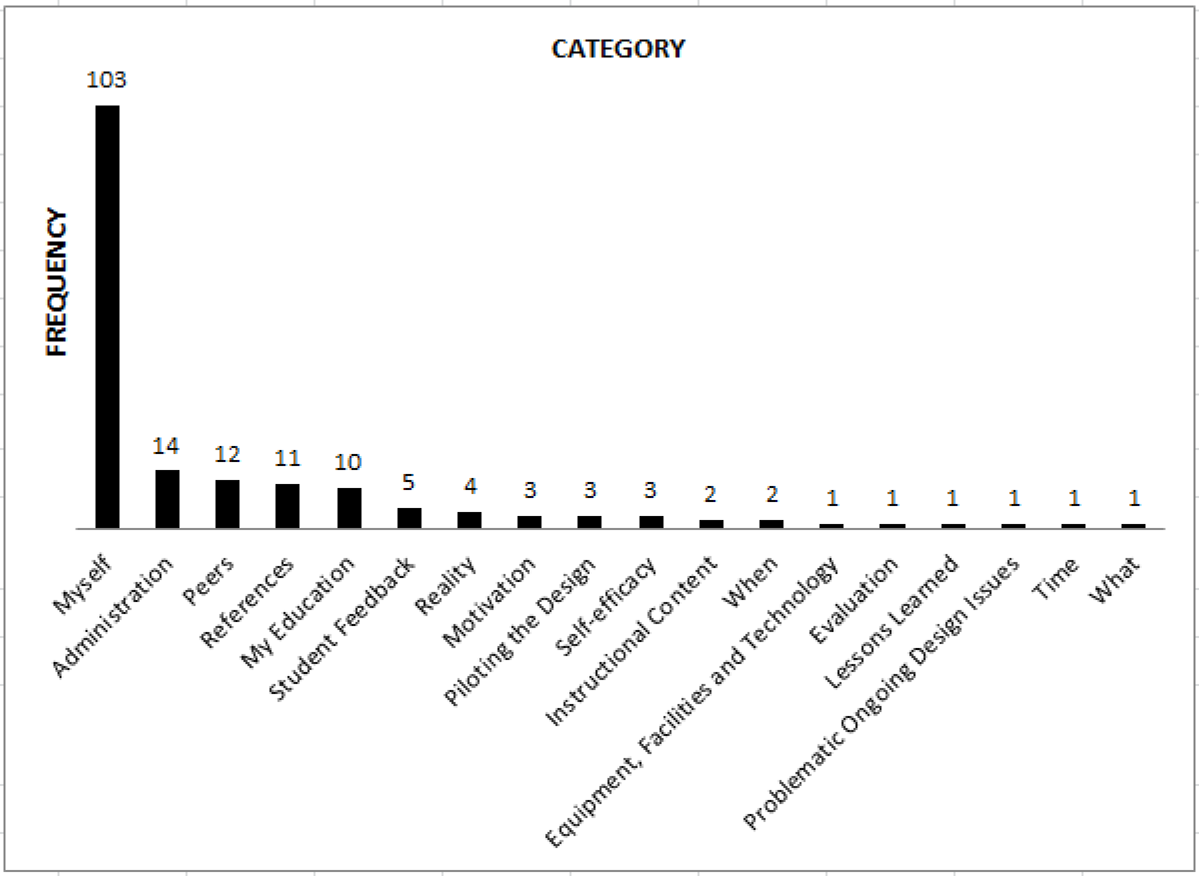


Figure 18. Source of Question - Frequencies per Data Category

4.5.5.1 Participant Quotes for Source of Question

The primary source of questions was the self (*Myself*), but there are some interesting insights associated with other sources of questions.

Myself (Self): “Past experience with students. I've seen students draw an opening 30 feet wide with a piece of glass 1/4" thick and I know that glass doesn't go that far.”

My Education: “Personal experience with busywork as a graduate student,” and “I'm going to give that whole thing to the college classroom course because I anticipate actually that through my experience with other professors who never think about this expert/novice divide thing, that I might not have ever come up with it on my own.”

Reality: “Reality woke me up - more complex than expected. I was learning at that time and had time to acquire skills before teaching.”

References: Review of current information on architectural design, National Public Radio, books, dissertations, articles, and the literature.

Motivation: "If I wanted to 'justify' some of this [learning new technologies] I would say I want students to stay intellectually hungry and not think that this is the end of the road."

The following response largely sums up the motivation for faculty to try new instructional design approaches and instructional methods:

Student Feedback: "Students prompted me to try this. They're my biggest concern and biggest ally."

4.6 Findings for Research Objective 3: Patterns of Behavior

RO3: To identify patterns of behavior in the descriptions faculty provide about their conceptual instructional design experience.

This section discusses patterns of behavior for steps, questions and question context.

4.6.1 Patterns of Behavior for Steps

Step data is important to provide context for questions. As no behavior patterns were identified at the coding level for steps, steps were analyzed for designing behaviors based on literature review and the researchers' experience. Step behaviors are:

- Coping with Newness
- Realizing Something New is Needed
- Learning (by Participants)
- Identifying a Problem
- Information Seeking
- Developing Instruction
- Considering Design Options
- Externalizing the Design
- Pilot Testing the Design
- Deciding on a Design Option
- Solving a Problem
- Considering Student or Employer Needs
- Evaluating Student Performance
- Implementing the Design
- Teaching (no awareness of designing)

Sequences and numbers of designing behaviors are not similar across participants. Some step behaviors, such as *Coping with Newness* appear to be more likely to occur at the beginning of the conceptual instructional design experience. Step behaviors such as *Implementing the Design*, *Evaluation of Student Performance*, and *Solving Problems* appear to be more likely toward the end of the conceptual instructional design experience. However, no definite or consistent patterns of step behavior were identified across participants. Refer to Figure 19 for the distribution of designing behaviors.

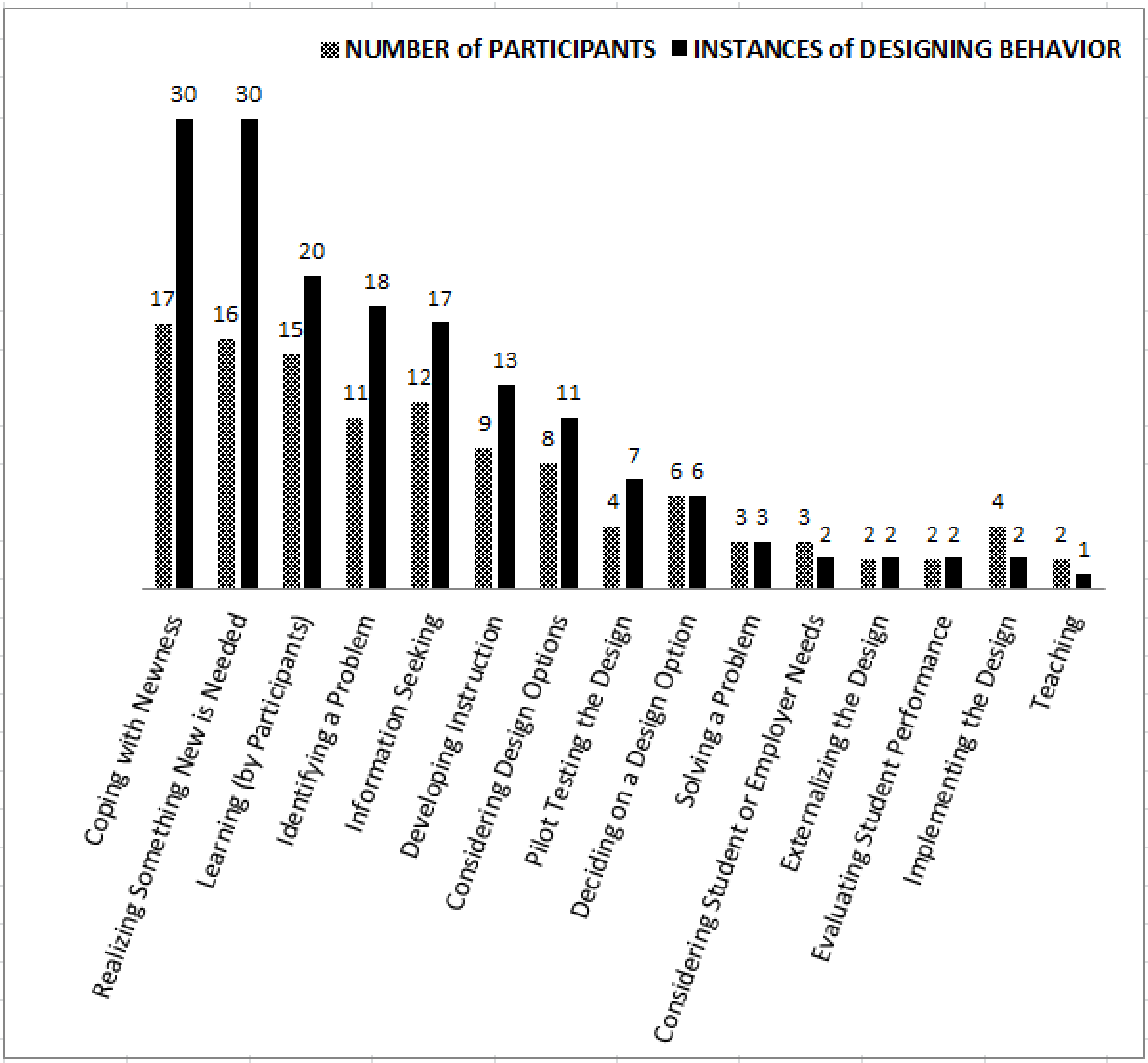


Figure 19. Number of Participants Exhibiting Each Designing Behavior (Steps)

Participants showed from three to ten different designing behaviors each. Behavior coding was limited to three behaviors per step. As a result, frequencies shown for designing behaviors should be considered approximate. The intent of this study was to explore designing behaviors rather than to obtain a comprehensive description of designing behaviors. Care must be taken not to overlay a detailed design process on early conceptual design. There are still many unknowns. In Table 18 a mini-case for Participant #17 is presented as an example of the range of behaviors for a single participant during early conceptual instructional design.

Some of the behaviors identified for steps were also visible across questions and question context, such as *Coping with Newness* and *Solving Problems*. Frequency counts are not provided for step behaviors that also extend across questions and question context. More detailed data would be needed to determine if these behaviors were distinct instances of the behavior or continuations of step behaviors.

There were also behaviors that were only identified across questions and question context. These behaviors are discussed in section 4.6.2.

Participant quotes for selected step behaviors are presented next.

Table 18. Example of Designing Behaviors for Steps

STEPS: PARTICIPANT #17	DESIGNING BEHAVIORS		
Students brought it up in class. Some of them had experience with Excel and wanted to move faster and others need to go slower to learn. I realized that Excel is so big, those who know it should be able to go ahead, but I need to be there for those who need it.	Realizing Something New is Needed	Identifying a Problem	Considering Student or Employer Needs
Decided to do a hybrid. Ten to 20 minute lecture on a new topic and then everybody can work on a [Microsoft Office Simulation platform] project at their own speed. If they know, then go.	Coping with Newness	Developing Instruction	Deciding on a Design Option
Went ahead and implemented the plan.	Imple-menting the Design	Coping with Newness	
I started to realize there were problems. I had to be prepared to work on anything anywhere students are [in the content] one-to-one. From basics to pivot tables.	Identifying a Problem		
Had to deal with students in different places [in classroom] who all needed help.	Coping with Newness	Identifying a Problem	
Take the students in groups to work with others who are working on the same chapter.	Imple-menting the Design	Coping with Newness	
So happy about that! I hear students figuring it out. They're focused, not on the Web. I hear them talking in pathways -- go to ___ and then click___. Teaching how to use the computer! I'm just thrilled. I've never seen that outside a programming class before. I'm happy about it when students are not afraid to click buttons in computer programs. Technology, everything changes. Instead of being afraid they know they can figure it out.	Learning by Participant – also students in this case.	Solving a Problem	

4.6.1.1 Participant Quotes for Selected Step Behaviors

Findings for step behaviors that are not listed in Table 18 are provided below with the exception of *Information Seeking* which is discussed in section 5.5.2.

Externalizing Design: There are several examples of faculty either externalizing design ideas through creation of diagrams, models, etc. or designing instruction for their students to create externalizations of designs. Here are the best examples of each:

> "I made a SWOT diagram (strengths, weaknesses, opportunities and threats) analysis, think and discuss, review of materials. It helped me reach a decision point."

> "I want to do a historical survey of case studies and have students create technical drawings of their own design. Covers technical data, representation of systems, drawing, and socioeconomics."

Considering Design Options and Deciding on a Design Option: "Worked with the other professor to review textbooks, choose text, and suggest lab work."

Teaching: "I did a brief presentation in class with the PowerPoint. I gave the students the PowerPoint slides and the tutorial."

Evaluating Student Performance: "Open ended projects are difficult to evaluate."

4.6.2 Patterns of Behavior across Questions and Question Context

This section discusses patterns of designing behavior identified across questions and question context. These behaviors were not identified in the steps provided by participants.

Question and question context-specific designing behaviors include:

- Coping with Novice/Expert Issues
- Experts and Novices having Similar Questions
- Asking Converging and Diverging Questions
- Asking Secondary Questions
- Dealing with Complexity
- Externalizing Design
- Coping with Diversity
- Self-checking
- Iterating

Behavior identification across questions and question context was found to be quite detail-intensive, as discussed further in Chapter 5. As a result, frequency counts are not provided for these behaviors. Instead, general indications of scope are included with the following participant quotes.

4.6.2.1 Participant Quotes for Designing Behaviors across Questions/Context

This section provides selected examples of participant quotes for designing behaviors identified across questions and question context.

Coping with Novice/Expert Issues: *Novice/Expert Issues* were raised by several participants with respect to being an expert trying to effectively teach novices, and as an expert encountering difficulty trying to transition to a new design/knowledge domain (expert in the position of a novice). Here are two excellent examples:

<u>Expert teaching novices</u>: "So there's this thing - I'm sure you've heard of it - called the expert/novice divide, right? And it's just that a lot of professors - frankly we are not the average student, we were the best student in all of our classes first of all - which makes us different from most of our students, and we've been doing this for so long that it seems like - it becomes to us the equivalent of how do I teach someone that two plus three is five. Like unless you've had some instruction on how do I teach someone that two plus three is five, it just looks so obvious to you that it can be difficult to figure out

a way to tell it to someone, except that - duh, two plus three is five! (Laughter). Why aren't you getting this?! And I'm actually very aware of this. I took a teaching course in grad school where we talked about the expert novice divide a lot - so we might be on to 'help' at this point, I don't know - and that very much helped me. That it's something that I try and think about always. But also experience in knowing that when I can anticipate at least some of the problems that students are going to have in the classroom, then that also helps make my lecture more effective because I've already got the answers ready for them, or I've already built it into the lecture so I'm not taking the extra time to address those things."

Expert in the position of a novice: "What I soon found out is that just because you're good at something you can't easily become good at something new until you put an adequate amount of time into it. You may have heard about spending 10,000 hours to really get good at something, and that strikes home on a very personal basis as I realized I cannot easily transfer my experience from one domain to another one. My background in physics and my interest in this helped, but it still takes quite a bit of effort to be as good at new things as things that span decades."

Experts and Novices Having Similar Questions: Several expert or very experienced participants who were involved in new design situations asked questions or had concerns similar to those of novices or less experienced participants. Refer to Chapter 5 for additional discussion.

Examples of questions asked by an expert dealing with newness:

> "How will students respond?"
>
> "What material am I going to teach?"
>
> "Do I know enough to do this?"

Example of concerns and questions from novices or less experienced participants

dealing with newness:

> "I'm not sure how students responded. I'm an international student and don't understand all the technical terms fully. I'm not sure explaining them to students. I'm not a technical person. What if students ask more questions? … I want to be able to explain why it's needed. I don't have the advanced skills."
>
> "How will students respond and how will this affect the flow of the course?"

Asking Converging and Diverging Questions: Converging (closed ended) questions narrow down a topic, and can often be answered with a yes or no, or with a walk down the hallway to look at a laboratory. Diverging (open ended) questions open up a topic and are likely to lead to additional questions. An example of participants' use of both converging and diverging questions is shown in Table 19.

Table 19. A Participant's Use of Converging and Diverging Questions

QUESTION	CONVERGING?	DIVERGING?
Did students have the right prerequisites?	X	
Are students prepared to take this?	X	
What are student's backgrounds?		X
What lab equipment is available to me?	X	
Make sure I had all the objectives. Cognitive domain, psychomotor, one method versus another method…am I writing good objectives?		X

Asking Secondary Questions: Many faculty asked secondary questions; additional questions generated within the context of the original question. Here are four of the most interesting examples:

> "When we say multimedia programming, what does that mean and what technology does that encompass?"

> "Concerns about the company [for co-ops] - what if it goes under? - or what if students need more knowledge?"

> "What if I don't look qualified? I easily get nervous - low self-esteem. It's visible to others."

> "What if I missed key information? I'm learning as I go, don't want to leave things out and hurt student learning."

Dealing with Complexity: Sometimes participants struggled with complexity of design, associated logistics, associated technology, or all three. Two of the best examples are:

> "Technology changes so fast, we're not aware of how much the landscape is changing and can't cope."

> "The [miniature] car had some gears to connect from the motor to the wheel and we want to machine those gears or purchase them - how easy or difficult? So the basis [for the question asked about appropriate level of detail for students' hands-on design project] is the reality of the complexity of the problem…. Can't be too complex or it will be a bad experience for students, disappointing. So many pieces to put together – and risk of it flopping."

Coping with Diversity: Several participants expressed concern about coping with student diversity in the classroom.

> "We have a very diverse body of students, so going from the informational side of the equation to more of the dynamic of the individual students themselves. The class - it's a presumption that I unfortunately have to make because it's a continuation of a beginning class; however I do not have the same student representation that I had from the previous semester. It's a mixed composite of students that I have had or previous instructors have had (I'm not the only one who teaches this class) and students who may have taken the introductory class a year or more ago. Need to acknowledge diversity and student's own expectations with the situation."

> "Students brought it up in class. Some of them had experience with Excel and wanted to move faster and others need to go slower to learn. I realized that Excel is so big, those who know it should be able to go ahead, but I need to be there for those who need it. Can I deliver instruction across that broad of a requirement effectively? I was afraid and still am."

Coping with Cross-Disciplinary Design: Many concerns were expressed about coping with cross-disciplinary design (or interdisciplinary design or multidisciplinary design), another area in need of design support, and of specific interest to the Finger Lakes Faculty Development Network. Here are two good examples:

> "I teach both groups (engineering students and technical students) and know their academic background and abilities are quite different. It was natural to be concerned about if the two groups would communicate properly."
>
> "I started to make up a plan as to how we will instruct the course. It was fairly complicated because I have two groups of students and it was multidisciplinary.

Self-checking: Verifying that a design task or tasks have been properly completed is necessary to ensure that instructional materials are accurate, all course requirements have been met, and learning activities are properly incorporated. Here is an example:

> "Make sure I'm covering what's needed for lab skills and integrating activities."

Iterating: Several instances of design *iteration* were identified. Examples are:

> *Example 1:* A participant has designed three separate classroom approaches to helping poorly-performing students to better learn materials; three design loops in a still-ongoing instructional design effort."
>
> *Example 2:* A participant selected a technology for lab use assuming the latest and greatest technology was what was needed. Two years later the participant discovered that much older technology was still in use in local high tech industry. The participant had to start over again to learn about the technology, revise the curriculum, and obtain the technology for lab use."

This concludes results for RO3. The next section covers RO4.

4.7 Findings for Research Objective 4: Big Picture

RO4: To explore what faculty feel is important about question-asking during instructional design.

Big picture questions provide rich data that may be of interest to other faculty, designers and faculty developers, as well as possible directions for future research. Big picture data is intended as a means for participants to share ideas they feel are most important about question-asking and the design of instruction.

4.7.1 Findings for Big Picture #1: Most Important Thing about Asking Questions

Students were focus of most responses, mirroring the emphasis on students throughout the data collected in this study. Overall, participants felt that the most important thing about asking questions during instructional design is:

- Creating an effective learning experience
- Identifying instructional purpose and/or goals
- Evaluating the design
- As a basis for information seeking and reflection

Interestingly, some participants answered the interview question with questions they thought were important rather than with why he or she thinks question asking is important. One response from a novice who had never heard of instructional design prior to participation in the study reflects curiosity about instructional design. Refer to Table 20.

Table 20. Big Picture Question 1: Most Important Thing about Question Asking?

Category	ID	Participant Responses
Creating an Effective Learning Experience (43% of responses)	1	Make sure I'm making the best use of student's time. Instructor's goals are to engage students.
	2	How to best get the knowledge across to the students?
	4	What kind of learning experience do I want to deliver?
	5	Will people with different learning styles than I have be successful?
	10	To ask questions rather than follow the text directly.
	13	In what ways am I designing the experience for students? Versus content - what to learn, challenge - want to develop thinking, have students take ownership of the experience.
	14	To transfer knowledge and experience and find a way to make a difference. Get across what instructor knows to the student. Questions are used to accomplish this goal. Address a spectrum of abilities and skills, not make excuses such as lacking background.
	17	How’s it going to be received by students? Is it going to help them? If so, how – change should make things better.
Identifying Instructional Purpose and/or Goals (28% of responses)	6	What are we doing and why are we doing it?
	7	What do you want students to be able to do, what content do you want graduates to have?
	9	What you want the student to be able to do specifically. More specific than understanding (fill in the blank) - what does that mean?
	11	I like what's the goal in this, what's my purpose in designing this, what will students get out of this.
	12	What is the purpose for this activity, curriculum, etc.? Without purpose you can have a fabulous design that's not useful.
Evaluating the Design (17% of responses))	8	How will I know students are learning?
	16	How relevant it is to the correlating industry.
	18	How will this help the students and can they do this?
Basis for Information Seeking and Reflection (6% of responses)	3	A. Based on inward reflection of experiences in class and an effective model to experiment with. B. Have time and space to discuss with colleagues. C. Time to read and research

Category	ID	Participant Responses
Other – Curiosity about Instructional Design (6% of responses)	15	Is instructional design for the people in academia like professors? What's the target of instructional design - for what type of person? Is it for any area, or a specific population? [didn't know what instructional design was until this interview]

4.7.2 Findings for Big Picture #2: Is There a Question You Wish You'd Asked?

All results for this question are potential candidates for faculty design support and professional development. Overall, participants wished they'd asked questions about (refer to Table 21):

- Time and effort required
- The big picture and/or how to do things
- Where to find help

When asked if there was a question they wished they had asked, about two thirds of the participants came up with one or more. One participant wanted to know all of the questions to ask.

Seven participants said there were no questions they wish they'd asked (not shown in Table 21). One of those participants specified that she expected to have more questions as the design progressed.

Table 21. Big Picture Question 2: Question You Wish You'd Asked?

Category	ID	Participant Responses
Time and Effort Required (17% of responses)	1	How much time would I need to set aside. I was surprised at the time required.
	4	Think about more realistically how quickly can I teach this? Want a slower pace next time.
	14	Needed to have a realistic estimation of time involved. Questions to be more realistic about what could be accomplished, to help address new domain, reduce defensiveness (self), and increase knowledge.
Big Picture and/or 'How To' Questions (28% of responses)	2	Should have asked better questions about the two groups working together in the beginning.
	3	Bounce off more colleagues. I was second guessing the technical component. How to make videos, should I be involved in production of those videos? How to find balance? All of these things take a lot of time and energy. Can I afford to take a more active role in development versus finding existing resources?
	8	How to systematically research the process [of going from research to course].
	18	What's the big picture?
	9	I have questions now that I'll be reteaching it. How to get students to be able to do what you want them to do - what's the best method? Active learning? Repetition?
	10	Best way to assess?
Where to Find Help (6% of responses)	11	Where could I get some guidance on this?
Other - Knowing All the Questions to Ask (6% of responses)	13	I wish I knew all the questions [I needed to ask] in advance.

4.7.3 Findings for Big Picture #3: Most Important Question to Ask Yourself

These results largely reflect concerns expressed by participants or related lessons learned. Overall, participant felt that the most important questions to ask themselves were about (refer to Table 22):

- Creating an effective learning experience
- Their own knowledge and abilities and/or the sustainability of their design

- Big picture or goals

Table 22. Big Picture Question 3: Most Important Question to Ask Yourself?

Category	ID	Participant Responses
Creating an Effective Learning Experience (50% of responses)	1	What's going to be most engaging? What makes things more tolerable for me and will help me grow the course?
	3	What would be my expectations from the students (realistically).
	4	Will this help students take ownership, engage, and walk away with needed skills and knowledge?
	5	How do you make the course accessible to people
	9	What are the possible things that the students won't understand?
	10	For topic - what do I define as success, partial success, or not at all for assessing students.
	11	Why am I doing this? What do I hope students get out of it? What can I learn from this experience? What do I enjoy, what's hard about this, what are interesting questions? What's hindering me?
	13	Same as for what's most important [In what ways am I designing the experience for students?], and am I trying to do too much at once?
	17	Same as for #1 [How's it going to be received by students? Is it going to help them?], and persevere, especially for major changes.
Own Knowledge and Abilities, Sustainability (39% of responses)	2	Do I have the right background and time?
	6	Do I know what I need to know?
	12	How does this fit with my own style? Will I actively be able to do this?
	14	Is what I'm doing going to be sustainable? Sustainable projects - that don't kill me.
	15	So far I'm only seeing things from my own perspective as a student. I need to look at things from the student perspective [of the students I am teaching]. I want to be easy to understand, helpful, organized, fair. I don't want to be disorganized or unfair, as I've seen as a student.
	16	Am I being clear?
	18	Can I do this and maintain energy and authentic learning?
Big Picture or Goals (11% of responses)	7	Does the ecosystem satisfy categories for entry singly and collectively?
	8	What's my goal?

4.7.4 Findings for Big Picture Question 4: Effect of Question-Asking During Instructional Design (or Not) on Quality of Instruction?

The responses in Table 23 show that participants really agreed that asking questions affects the quality of instruction. These results reflect the value participants see in asking questions during instructional design. Overall, participants felt that question-asking during instructional design has the following effects:

- Helping to avoid problems and/or complacency
- Supporting development of good learning experiences
- As a driving force for design
- General positive effects
- Generally a positive effect but doesn't always help
- A key aspect of externalization of design

Table 23: Big Picture Question 4: Effect of Question-Asking During Instructional Design (or Not) on Quality of Instruction?

Category	ID	Effect of Question-Asking (or Not) on Quality of Instruction?
Avoiding Problems and/or Complacency (28% of responses)	1	Huge difference. Tend to ask/anticipate. If not, have to backtrack when obstacles come up. Questions lead to ideas to avoid obstacles.
	12	Leaving out important questions will likely result in an unsuccessful design. Naive, can think you're on target - but are not. Didn't realize, hadn't/can't ask important questions.
	14	Without asking questions I may settle for what I have instead of the best or how to improve.
	15	If I overlook questions, later I have the same problem and can't avoid the problem. Example: I know I'm not confident and avoid questions, but then I get more later! I will have the problem eventually - have to think and prepare.
	17	Have to constantly question everything you do. Could I have done it better? Can't get complacent.

Category	ID	Effect of Question-Asking (or Not) on Quality of Instruction?
Supporting Development of Good Learning Experiences (22% of responses)	4	Asking questions as designing is really important to create the learning experience you want. If you leave something out then you need to find a way to work it in.
	5	Example: if you're writing an exam and leave words out and students don't get it. Hurts me and students. Need to take the time to look through other people's lenses.
	9	Students are usually more comfortable when you've given thought to questions, and may be more successful as well.
	10	There's no comparison. If I don't ask questions, things will be disjointed and students don't learn. If you're not asking questions, you're not teaching.
A Driving Force for Design (22% of responses)	3	Never can ask enough questions. Time constraints - need to find the questions to move procedurally-based. Find possible barriers versus taking off readily and being embraced.
	7	Yes, it's very important. Information and data drives instructional design. If you're missing data the curriculum will suffer.
	8	Can't imagine how to do instructional design without asking questions. There's no one way to do things.
	18	Keeps it granular for students and faculty. Change – a living thing.
General: Positive Effect (11% of responses)	2	Very important to do before starting design!
	11	It makes a huge difference!
Positive but Doesn't Always Help (11% of responses)	13	There will be mistakes. Best to anticipate questions, but need to convey this to students - what it's like to be a teacher. Want to solve problems.
	16	Most of the time it helps it, but if you ask questions too much it can make it less concise.
A Key Aspect of Externalization of Design (6% of responses)	6	When teaching design, the act of making drawings or models is simultaneous with knowing (also not knowing). Need open-endedness. What to need to know?

4.7.5 Findings for Big Picture Question 5: Other Effects of Your Instructional Design Experience You Would Like to Share?

This was the most open-ended question of the interview, resulting in a wide range of responses. As can be seen in Table 24 below, most participants felt they had a positive instructional design experience. Some learned about their students and some learned about their own teaching or design. Most importantly, everyone agreed on the importance of question asking during conceptual instructional design.

One participant pointed out a general need for more instructional design training for faculty.

Results primarily reflect:

1. Positive experiences showing enthusiasm, confidence, curiosity and motivation.
2. What participants learned from their instructional design experience.
3. Faculty questions, concerns, and the need for design support and professional development.

Findings for Dervin's Sense-Making are presented in the following section.

Table 24. Big Picture Question 5: Other Effects of Your Instructional Design Experience You Would Like to Share?

Category	ID	Participant Responses
A Positive Experience for Me (61% of responses)	1	Made me more responsive to students and the needs of students. I learned a lot.
	2	Enjoyed it and would do it again. A positive learning experience.
	4	Helped me be more rigorous. SWOT was helpful.
	5	Forces me to be well prepared so students don't call me out.
	6	Didn't appreciate the course before. Now I understand the importance to me and the curriculum.
	7	Very positive - I'm still here!
	8	It feels good to practice in class what I teach about and research.
	11	It's been generally positive. I'm excited to see how students will respond, engagement - I haven't taught it yet. It's neat to take ownership and put this together. And curiosity how will it work.
	13	It's exciting when it comes together -
	15	It helped me to go back to what I did as a student - I didn’t really think about steps in teaching. I more critically evaluate my performance.
	18	It’s affected how I teach other classes – I’m trying [my ideas] over there too.
A Positive Learning Experience with Some Negative Aspects (17% of responses)	3	I had a lot of expectations - this [changing to a partially online course] would free up time for working one-on-one with students. Didn't mesh as well as I would have liked.
	12	Confirmed my knowledge of technology and that I could learn to do it and meet instructional needs. A lot of inadvertent and unnecessary complexity. I felt accomplished.
	14	I learned - open-ended projects work, but best tied to skills for other classes, rather than just interests. That resulted in tons of non-relevant stuff for me to learn and evaluate. I realized I don't need to know everything. I can have others help and partner with other instructors. This project doubled my teaching load - I need to be more in a managerial role.
General Comments (17% of responses)	10	Backward design. Need forward design first to learn it.
	16	Sometimes it's more helpful to encourage other resources than just relying on myself, which is not realistic at all.
	17	I care about how it affects students. If they learn something I’m happy!
We Need Instructional Design Training (6% of responses)	9	As college professors we're not trained enough in instructional design. Most of what we learn is handed down colleague to colleague. I've learned good things at seminars.

4.8 Findings for Dervin's Sense-Making

Findings for the primary Sense-Making data categories of steps, questions, and question context were covered in sections 4.3 through 4.6. This section presents findings for Dervin's Sense-Making in general. The Sense-Making data showed that participants used questions and information seeking to help them make sense of their instructional design situation and help them move forward with their design.

> ***Examples:*** "Asking questions improved my understanding," and "I read the course description over carefully and started trying to find a textbook."

Background: Brenda Dervin's initial data analysis approach of 5W's and an H, Plus (Who, What, Where, When, Why and How, Plus other typical Sense-Making categories) was applied to study data (B. Dervin, et al., Editors, 2006). All data coding categories were associated with at least one typical Sense-Making data analysis category, Refer to section 3.11 for more information on how Sense-Making data categories were applied in conjunction with emergent coding categories.

4.8.1 Examples of Findings for Dervin's Sense-Making

Several examples of Sense-Making data categories are listed below with explanation and examples of each.

Attitudes and Emotions (coded as *Reality*): A participant's outlook, mood or feelings.

> *Example:* "So happy about that! I hear students figuring it out" and "Can I deliver instruction across that broad of a requirement effectively? I was afraid and still am."

Barriers/Constraints (coded as *Reality*): Anything that halts or hinders participants' forward movement during the instructional design experience.

Example: "The traditional model for hands-on student-based instruction is six hours per week. We work with a model that has four hours a week. Limited time constraint, which is fine, it hones you in terms of being more efficient, but it's still the reality of what is done when something is made is there still needs to be some accountable amount of time for each step in the process."

Goals: What the participant wants to accomplish during the instructional design experience. For the purposes of this study, goals focused on solving problems identified during early conceptual instructional design.

Example: "Yes, course is progressing nicely. Students get frustrated if we don't have time to discuss!" or "Partial. I'm still not convinced."

For details on Sense-Making data coding and results, including frequency counts for specific data categories, refer to Appendix N. A brief excerpt from Appendix N is shown in Figure 20.

Dervin's Five W's and an H, Plus	Coding Category	Totals	% of Total Codes	STEPS	QUESTIONS	BASIS (Why)	HELPS	HURTS	ANSWER	SOURCE
				100	157	157	152	139	146	157
How	Evaluation	7	0.6	2	1	2	0	0	1	1
How	How (General)	72	6.0	8	47	2	5	1	9	0
What	Administration	31	2.6	3	3	6	4	0	1	14

Figure 20. Excerpt from Appendix N – Sense-Making Data Frequency Counts

The high-level Sense-Making categories are in the first column, Dervin's Five W's and an H Plus. Lower-level, more detailed coding categories are shown in the Coding

Category column. Refer to Appendix M for the final codebook and sample responses. Frequency counts for Steps, Questions and Question Context are displayed in the remaining columns of Appendix N. A total of 1008 items were analyzed, with up to three codes allowed per item for 1204 codes applied in total. Coding categories with the highest percentage of responses are summarized in Figure 21.

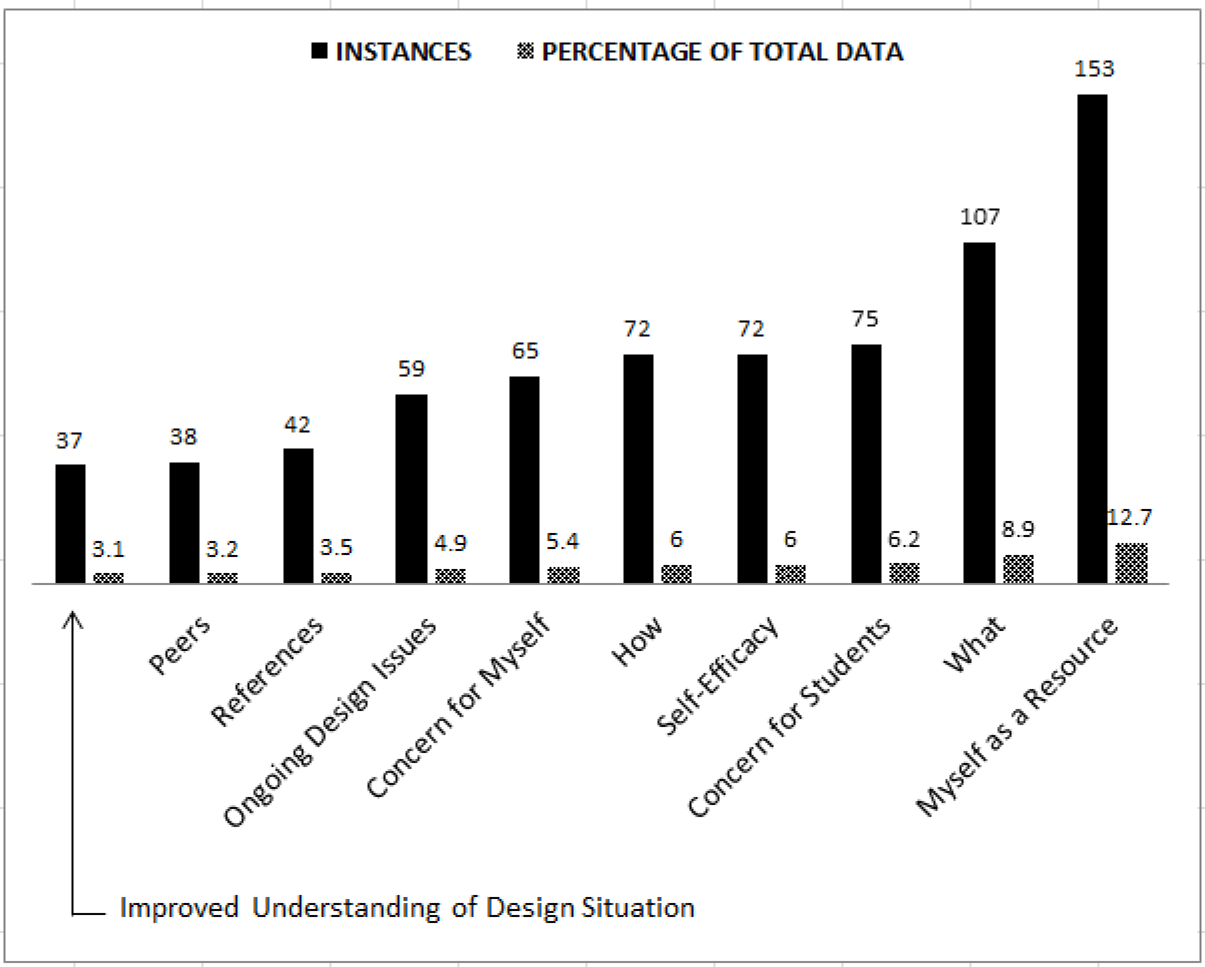


Figure 21. Most Common Coding Categories

4.9 Findings for the Ad-hoc Design Mapping Analysis

This section presents the results of the ad-hoc design mapping analysis. Design mapping supports generalizability of the study results, as discussed in section 3.7. Details on the development and implementation of the ad-hoc design mapping analysis are provided in Appendix O.

Design mapping identified similarities between the questions asked by faculty during their instructional design experience and questions asked by designers in other design domains. Design mapping team members analyzed the questions and question context collected from study participants for conceptual instructional design. Then they mapped those questions to their own design domain(s) by identifying similar questions in their own design domain(s).

4.9.1 Selected Examples of Design Mapping Responses

Selected examples of design mapping responses are shown below in Table 25. Examples were selected to illustrate the range of design domains that were mapped. The table contains:

1. The question or concern expressed by a study participant: higher education faculty for an early conceptual instructional design experience.
2. The mapper identification number (Mapper #1, #2 or #3) and the mappers' design domain for that specific response.
3. An example of a similar question or concern in the mappers' design domain (My Design Domain).

4. Mapper comments (optional). The mapper comments provide some excellent perspectives on design experiences in other disciplines.

Explanation of the design domains is provided in Appendix O, Table 26.

Table 25. Examples of Design Mapping Data

Faculty Question or Concern (Instructional Design)	Mapper and Design Domain	Example of a Similar Question or Concern in My Design Domain	Mapper Comments (optional)
Knowing the most common disease cases that would be tested for.	Mapper #1: Nuclear Design Engineering	Knowing the risks, most commonly encountered problems, and industry concerns for transient analysis.	Industry seminars and working groups, IEEE. Expectations, tools, programs. Benchmarking!
Did students have the right prerequisites?	Mapper #3: Psychosocial Evaluation	Does the patient meet criteria for this level of care?	
Concerned that students might have formal/conceptual approaches only and might not be able to get to thinking technology fast enough.	Mapper #2: Designing a software tool for wholesale electric power scheduling and financial settlement.	What level of interaction needs to be built into the tool?	Too much interaction reduces the benefit of having a tool. Too little interaction turns the operator into a button pushing monkey unable to understand and deal with occasional problems.
How to present material with appropriate depth and make it relevant to students.	Mapper #1: Nuclear Design Engineering	How to present material with appropriate depth and make it relevant to students.	Apple pie - a classic question that's applicable to any design situation.
How do I structure this activity? Dividing up material for the syllabus.	Mapper #2: Transmission congestion hedging in wholesale electric power markets	How do I structure this activity?	Dividing and sequencing the information is often more art than science.

Faculty Question or Concern (Instructional Design)	Mapper and Design Domain	Example of a Similar Question or Concern in My Design Domain	Mapper Comments (optional)
Had to coordinate schedules to reinforce each other, but that's not always possible.	Mapper #3: Piano Tuning	When during set up can I get in and have the quiet necessary to tune the piano?	
How to do this without tasting?	Mapper #1: Nuclear Design Engineering	How to do tasks involving color identification?	Like being colorblind - most people don't think about it - can't discern differences, need alternatives. Materials shouldn't restrict anyone.
How would the two groups work together? Would that be difficult to incorporate? They're very similar fields but they're different levels. One is more analytical, more theoretical group of students; the others are more hands on. I was wondering how that would work out.	Mapper #1: Nuclear Design Engineering	All involved groups need to be able to work together as a team.	There are cross-disciplinary requirements for us to work together. An obligation to provide coaching. If a concern is identified, provide training on building blocks. Need to communicate in terms that relate to them.
How faculty opened the floor for students to offer critiques.	Mapper #3: Organizational Psychology	How to create environments that feel safe enough for open dialogue. How can trust be developed within the hierarchy of command?	
Knowing the most common disease cases that would be tested for.	Mapper #2: Nuclear Power Plant Operation	Do I know the most likely `common mode' failures for pump and valve components?	Lessons learned from our own and other similar plants' problems are analyzed by a separate distinct work group and incorporated into procedures and work practices.
How many work hours, shifts, workplace environment and culture, hands on experience needed before starting?	Mapper #3: Selling Cars	What are the primary drivers of the customers` need for a vehicle? Which are emotionally the most powerful?	

4.9.2 Design Mapping Success Rate

Design mapping data was analyzed by determining the percentage of study participant's questions that were successfully mapped to questions in the design mappers design domains. Mappers were provided with a set of study data from the first 14 study participants, attempting to map an average of 112 questions each. Mapping frequency counts are provided in Appendix O, Table 27.

The extent of design mapping success can be evaluated in two ways:

A. Percentage of questions mapped from the study to other design domains.
B. Number of design domains mapped.

The average percentage of questions successfully mapped was 93%. A total of 47 design domains were mapped: 13 from commercial nuclear power and 34 from non-nuclear design areas. Refer to Figure 22. This was an unanticipated level of success. No literature could be found in which design mapping of questions across design domains was investigated. The researcher and design mappers learned by doing throughout, including development of the ad-hoc analysis. The anticipated success rate was 25 to 30 percent.

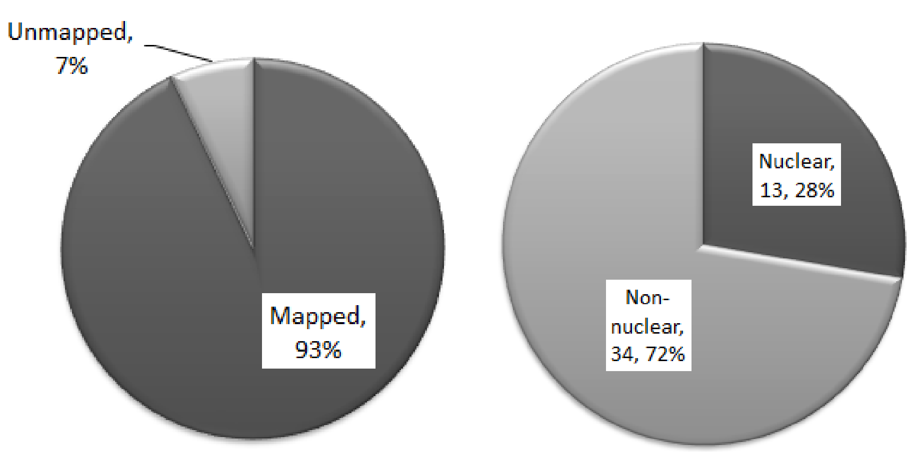


Figure 22. Design Mapping Percentages and Domains

4.9.3 Design Mapping Visualization

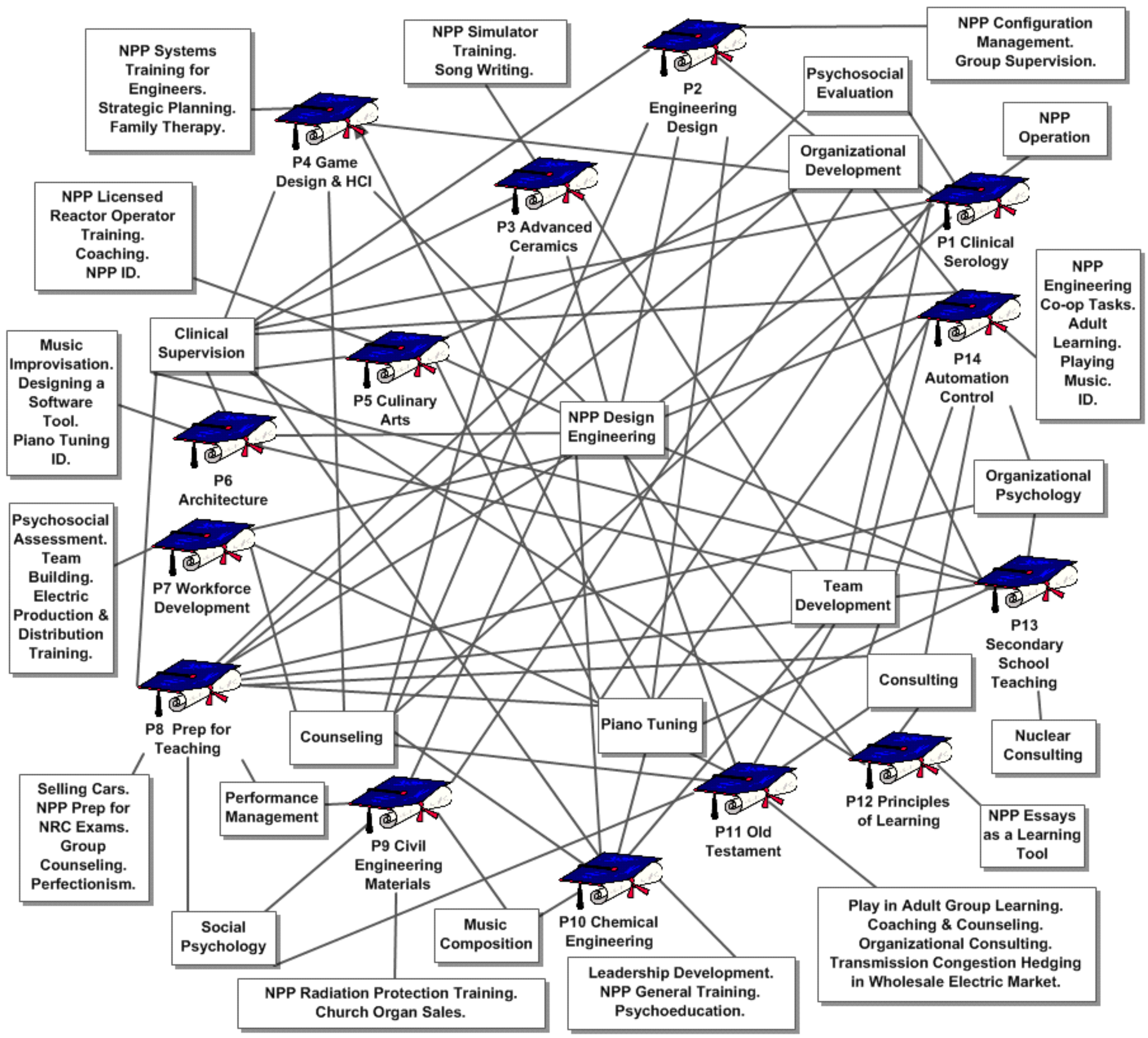
The design mapping diagram shown in Figure 23 illustrates the interconnections of design domains between study participants (higher education faculty) and the design mappers’ design domains.

Faculty participants are indicated by a graduation cap symbol labeled with the participants’ identification number and the subject matter area of their instructional design experience. Design mappers’ domains are indicated by text boxes containing the name of the design domain. Abbreviations are used for Nuclear Power Plant (NPP) and Nuclear Regulatory Commission (NRC).

Lines connecting design mappers’ domains to a participant indicate that questions from the participant were successfully mapped to the mappers’ design domain(s).

Participants show design domain mapping relationships for a low of four other domains to a high of eight other design domains. Mappers were not provided with a specific game plan for mapping domains, but were left free to develop their own approach (refer to Appendix O, section O.6). Mappers worked with from one to 33 domains and could choose how many times they wished to attempt to map to a specific domain. The number of interconnections to a given design domain is tied to how many times a mapper chose to apply that domain. For example, Mapper #1 worked only with the Nuclear Power Plant Design Engineering domain and applied that domain to all questions mapped. Mapper #3 only applied the Consulting domain to four questions. Refer to Appendix O, Table 27 for more information.

The Design Mapping Diagram suggests that participants' questions are transferable to an extent to other design domains. This supports the concept of design as a discipline by illustrating similarities in questioning behavior across multiple design disciplines.



KEY		
	(mortarboard icon)	Academic Instructional Design Domain
	(box)	Other Design Domains
	(line)	Indicates Mapping of Questions from Academic to Other Design Domains
	NPP = Nuclear Power Plant. ID = Instructional Design. NRC = Nuclear Regulatory Commission.	

Figure 23. Design Mapping Diagram

This concludes Chapter 4. Chapter 5 discusses study findings and provides recommendations.

CHAPTER 5. DISCUSSION

"Most questions are fundamental to the overall process of designing a solution and differ primarily in the details of the answer rather than the form of the question."

- Lance Hubbard, Nuclear Power Subject Matter Expert and Design Mapping Team Member, with permission.

5.1 Introduction

This study provides an in-depth view of the cognitive questioning behavior of 18 higher education faculty as they progress through early conceptual design involving at least one thing that is new to them. Brenda Dervin's Sense-Making Approach was applied to obtain data on instructional design situations, steps (actions), questions/concerns, and question context. Data was analyzed using deductive and semi-inductive content analysis and design mapping. Efforts were made to ensure data reliability and validity.

This chapter discusses the results presented in Chapter 4. Also included are discussion of the use of Devin's Sense-Making Approach to investigate a small part of a large complex behavior, strengths and limitations of the study, recommendations, future research, and conclusions.

Results support the initial concept of the study: questioning is critical to design synthesis, supporting learning, problem identification and solving, creativity, evaluation, decision making, and identification and reduction of uncertainty. Faculty needs for design support and professional development were identified. The ad-hoc design mapping analysis suggested transferability of question-asking behavior across multiple design domains, supporting the concept of design as a discipline.

5.2 Participants' Steps

Steps reflect actions taken by users. Something New (*Coping with Newness)* was the only step that was common across all participants. Other steps covered many topics, often involving increasing complexity and uncertainty (*what* to do for cross-disciplinary audiences, *how* do I ___?), but without a shared sequence of steps across participants.

This contrasts with some Sense-Making research on more linear behaviors, in which a sequence of steps can fairly readily be identified. For example Nilan and Mundkur investigated online purchasing behavior and described participants' step sequence as: realization of a want/visiting a website, browsing/searching, comparing, researching, selecting, purchasing or not, entering information, stopping, and saving data (Nilan & Mundkur, 2007).

Newness and the associated complexity of participants' early conceptual design experiences resulted in more complex data coding and analysis than what I had done in previous Sense-Making research. This was necessary to investigate and illustrate the complexity that faculty can encounter in early conceptual instructional design. This study identified many opportunities for provision of design support and professional development for faculty. Identifying faculty concerns about complexity may provide opportunities to help faculty deal with and/or reduce complexity in instructional design.

5.3 Participants' Questions and Concerns

Question findings indicated a need for design support across the sample. Questions asked by faculty were often very situation specific. Faculty had from 5 to 15 questions/concerns each during their early conceptual design experience and generally expressed additional questions/concerns during discussion of question context. Like the findings for steps, this reflects the complexity of designing.

Concerns about feedback from students and employers and concerns about student retention were expressed adamantly by multiple participants. Feedback from students and employers was critical input for faculty design decisions, and often a source of motivation and inspiration. Student retention concerns centered around how difficult it is for freshmen to grasp what design is, the scope of design concerns and issues, or how coursework ties to future career directions. These concerns are important because they indicate situations where targeted design support and sharing of instructional design experiences could benefit a number of faculty through seminars or workshops.

5.4 Uses Faculty Associate with Their Questions

Uses include basis for questions, helps, hurts, how an answer helped and source of question. Uses are important for identifying faculty needs and developing best practices.

Basis for question findings convey `why' and are important because they provide insight on the reasons behind the questions and concerns faculty had. The 'why' may point to a design support or faculty development solution that could minimize the potential for that question or concern in the future.

Helps are important because they indicate specific actions or resources used to move forward in the instructional design situation. Helps may provide insights that could be useful to other faculty, such as how to motivate students for difficult course content or how to address a range of student skills and abilities in the classroom. Helps are a good starting point for development of best practices. Helps can also be combined with lessons learned from hurts to provide well rounded examples for design support and professional development (covering the good, the bad, and what to watch out for).

It was noticeable that although *peers* were mentioned frequently as helps, no participants specifically mentioned contacting a faculty developer, center for teaching and learning, center for excellence, etc. Participants were not specifically asked about use of on-campus resource centers or faculty development support, so it is unknown whether any were actually used. This is an area that could be addressed in future research.

Hurts communicate very specific problems that participants have struggled with. Hurts are important as they generally are direct indications of potential issues to be addressed through instructional design support and/or professional development.

Participants at several institutions used the word '*reality*' with respect to design barriers or constraints to indicate a negative situation that just had to be accepted and dealt with. *Reality* includes issues such as:

- Class size, available class time, prep and grading time requirements, etc.

- Mismatches between administrative or external perspectives on the readiness of high school graduates for college courses and what instructors observe in the classroom.
- Concerns about students who lack career-related skills, computer skills, or critical thinking skills
- Negative student attitudes toward education and educator.

Some *reality* concerns can be long term hurts that can severely impact faculty's jobs or that faculty may feel they can do little to address. Others, such critical thinking skills, can be addressed in the classroom, but are not easy problems to solve and rarely have comprehensive solutions. '*Reality*' concerns identified in this study appear to be issues that would likely require attention beyond that of design support or professional development such as departmental or administrative involvement. Focus groups or surveys could be helpful to explore '*reality*' concerns.

Stops occur when forward progress on a design is halted, generally with negative consequences (B. Dervin, 1983). Several examples of stops were identified including *design fixation*, a lengthy delay of a critical program development effort, and a design that potentially was not useful. *Stops* are examples of hurts that can have substantial negative consequences for faculty, students, and programs (personal, academic, and/or financial). Design support could help reduce negative consequences of stops and minimize the potential for future stops.

Knowing how an answer to a question helped faculty during instructional design can contribute to our understanding of design process and contribute to design process improvement. Study results show that success at finding ways to help themselves with design problems improves faculty self-efficacy. Providing faculty designers by assignment with training on instructional design could help faculty to better help themselves, benefiting both faculty and students.

Sources of questions help participants to bridge gaps (B. Dervin, et al., Editors, 2006). Sources provided interesting insights on issues, such as why students need real-life design projects with guidance from faculty (I've seen students draw an opening 30 feet wide with a piece of glass 1/4" thick and I know that glass doesn't go that far”). Some faculty shared how prior education influenced their design choices, for example by avoiding busywork, paying close attention to novice/expert differences, and trying to find ways to get students to understand the need for lifelong learning with respect to our rapidly changing technology and world. These experiences would be helpful to share with new faculty who may be struggling to cope with student expectations and diversity in the classroom.

5.5 Patterns of Behavior

Patterns of behavior portray repeated actions people take during design, useful to better understand the design process. Identifying patterns of behavior helps chunk a complex behavior into simpler activities and may identify areas in need of support or attention. This section discusses the following behaviors:

- Step Behaviors
- Information Seeking
- Coping with Newness and Uncertainty
- Novice/Expert Issues
- Asking Secondary Questions
- Dealing with Complexity
- Iteration

5.5.1 Step Behaviors

Step analysis is important because it shows a wide range of activities early in conceptual instructional design. This shows that use of Dervin's Sense-Making approach can identify a range of designing behaviors during investigation of a small part of a larger complex behavior.

No definite patterns of designing behavior or sequences of designing behavior were observed across participants for steps. Participants showed from three to ten designing behaviors. This is a useful result because it shows the potential complexity of design even at the earliest stage of conceptual instructional design. These findings show how quickly faculty can go from finding out they have a new design issue to deal with to being in the middle of a complicated and possibly critical design situation.

The scope of designing activities explored in this study was guided by not overly taxing participants. This study looked only at question-asking behavior during early conceptual design. It is possible that capturing data for additional design steps could lead to identification of some regularity in step behaviors across a larger span of the design process. That is a potential area of investigation for future research.

Information collected on the larger design efforts associated with most participants instructional design experiences or training participants had on instructional design was coincidental only. For that reason, terms used to describe designing behavior are generic in nature. For example, the term '*Considering Needs*' is used to describe what would often be referred to as a needs analysis. Without additional data on participants' instructional design experience and training, it could be misleading to assume, for example, that all participants who mentioned student needs must have done a needs analysis. Some participants had the background to perform a full needs analysis, but others may not even know what a needs analysis is.

The step behaviors are reflected in various design models and instructional design and learning theories and models from the literature. This shows that study results for step behaviors during design are reasonable and increases reliability of this study. Three examples of ties to design-related literature are:

1. The tasks of *considering needs*, *developing instruction*, *implementing* instruction (i.e. testing the design or teaching) and *evaluating* student performance are reflected in the many flavors of the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Molenda, 2003). Pilot testing of instructional design was performed as both a development and implementation activity, and can be viewed as formative evaluation (Scriven, 1981). This study supports the ADDIE concepts and the use of pilot testing as formative evaluation. Participants performed ADDIE tasks, although not all participants performed all of the ADDIE tasks within their conceptual instructional design experience. Faculty who performed all of the ADDIE tasks generally were involved in some form of pilot testing their design and applying results to improve the design. That supports Scrivens' view of pilot testing as formative evaluation.

2. Various aspects of *problem solving* and *decision making* have been associated with designing behavior from Newell's artificial intelligence research to the present. Problem solving and decision making have also been associated with abductive

thinking and sensemaking behavior, including information seeking (B. Dervin, 1998, 2000; Kolko, 2010a; Simon & Associates, 1986). Design Studies literature discusses decision making, externalization of design and design fixation (Cardella, et al., 2005; Cross, 1998; Purcell & Gero, 1996). This study supports these concepts. All participants showed *sensemaking* behavior and some form of *information seeking* behavior. Many participants made decisions as part of their conceptual instructional design experience and were involved in problem solving. Several participants brought up the usefulness of *externalization of design* (outlines, sketches/diagrams), and one mentioned design fixation.

3. Learning theory also comes into play. For example, participant 17's experience (refer to Table 18) is an excellent example of expectancy-value theory (Savolainen, 2011). After students asked to be able to move at their own pace in his class, he had some fears about his ability to meet their needs. But he was motivated by his expectations that the students could potentially really benefit from a new instructional approach, as could he. Refer to section 2.4.4 for additional discussion of expectancy value theory and motivation with respect to RO4.

This concludes discussion of step behaviors. The following sections discuss common behaviors identified across steps and questions and/or question context.

5.5.2 Information Seeking

Information seeking was the most common design behavior, interwoven through each participant's instructional design experience. All data categories included some form of *information seeking* behavior (Steps, Questions, Question Context). A definite need for information seeking support was identified, especially for locating appropriate resources and learning about means of instruction, assessment, and evaluation. This is important as these are areas that could be directly addressed through design support and professional development.

Hurts related to *information seeking* were few but reflected negative consequences such as:

> "Answers could limit what I could do for instruction"
>
> "Fear of what colleagues would think if questions sounded stupid."
>
> "If I'd talked to someone and they were negative that could have been detrimental."

All participants performed at least one *information seeking* activity, and many had several, almost always with at least some positive results. While some of this *information seeking* was expected because the design involved something new, it is interesting that additional questions and concerns were so wide ranging across the entire context, often involving multiple topics other than the new aspect. In Sense-Making studies of more linear, less complex behaviors, that level of interwoven information seeking may not be present. This is likely another indication of the complexity of design. Information seeking does appear to be a critical path activity for designing, supporting all design activities. In light of the range of questions and concerns identified in this study, this implies that design support could potentially be helpful for all design activities.

5.5.3 Coping with Newness and Uncertainty

Coping with Newness is a very basic skill for designing behavior, as by definition, design involves some aspect of newness/change. Design literature tends to focus on newness from the perspective of novel ideas and creativity, which may be associated with realizing there is a need for something new (Baldaia, 2012; Buchanan, 1992; Cross, 2011; Dym, Agogino, Eris, Frey, & Leifer, 2005). The idea of *coping with newness* as explored in this study appears to be more of an effort by participants to reduce uncertainty about the instructional design situation and identify and solve problems. This fits with Dervin's perspective of Sense-Making as a form of uncertainty reduction (B. Dervin, et al., 2003b). The distinction between innovation and reducing uncertainty is important. Resources and support solutions for innovation may differ from resources and design support for problem solving and dealing with uncertainty and complexity. That could be an interesting area for future research.

Anxiety was expressed by both inexperienced and very experienced faculty when trying to cope with newness. This was in part concern about whether they were really helping students learn, and in part about their own abilities and effectiveness performing design and implementation of instruction. Design support to help faculty learn about instructional design options, applicable instructional techniques, etc., could be useful to improve faculty skills and reduce anxiety.

Concerns about student reactions to new instructional approaches were expressed by approximately 66% of participants. Having this feedback from students provided at a least general direction for redesign of instruction, but these participants tended to be quite anxious about their ability to meet student expectations and their own expectations. This applied to both inexperienced and experienced faculty. There could be a variety of reasons for this, such as increased expectations from students, or the need to go in a new instructional direction on short notice. This would be an interesting topic for future research.

Overall, provision of design support and faculty development to address faculty concerns associated with coping with newness could improve the instructional design and instructional skills of faculty and reduce the number of questions and concerns they have when dealing with new aspects of instructional design. That could potentially reduce time, effort, and stress for faculty.

5.5.4 Novice/Expert Issues

Two types of *novice/expert issues* were identified: faculty coping with novice and expert (or more advanced) students in the same class, and expert and novice (or less experienced) faculty having similar questions when dealing with something new.

Coping with novice and expert students in the classroom is a form of dealing with student diversity. Refer to section 4.6.2.1.

Several instances were identified where experienced faculty asked questions similar to those of novice faculty. Experts encountering something new may be, from a practical standpoint, temporarily in a novice role and could require types of design support that they would not normally need. While there is not a word-for-word match, some of the issues at root are similar, such as not knowing who to contact for help.

This was an interesting finding, but no literature has been located to support it. More research would be needed to determine if this was an anomaly. However, this may indicate that it could be useful to survey both experienced and novice faculty when trying to determine needs for design support. If experienced faculty can experience difficulty with tasks such as locating applicable campus resources when they are in a new instructional design situation, others may be likely to have similar difficulties. Identifying questions asked by both experienced and novice faculty could target areas for design support with the potential to aid many faculty. This could potentially improve both the design process and faculty's' designs.

It was also noticed that both novice and experienced faculty admitted to fear of colleagues thinking their questions are stupid. It is somewhat disturbing to identify fear of asking questions in an academic environment. Optimally, all design environments should encourage questions as means to create and maintain quality designs, a sound but living design process, and safety.

5.5.5 Asking Secondary Questions

This is an interesting finding that deserves to be investigated further; a chaining of questions. In Sense-Making research performed in previous studies involving much simpler linear behaviors, additional questions would crop up occasionally and were treated as additional primary questions. That was reasonable for short interviews with straightforward context. In this study, having to back up to create an additional primary question every time an additional question cropped up in context would have seriously slowed down the interview process. As a result, unless a secondary question was about a very different and important topic, secondary questions were simply rolled into the question context data and were not analyzed separately. Participants were asked if a question was a whole new concern or not. In almost all cases, the secondary questions were an interrelated chain. This is an area that needs evaluation prior to future research.

5.5.6 Dealing with Complexity

The ability to *deal with complexity* during conceptual design is critical and was stressed repeatedly at the ICAD 2013 conference. This is an area of need for design support. Refer to sections 1.2 and 2.6.8 for discussion of the importance of conceptual design and complexity.

Complexity also comes into play with respect to Dervin's Sense-Making Approach. Savolainen (2006) has speculated about the methodological limitations of Dervin's step-taking and gap-bridging metaphors for the description of cognitive activities. He wondered if viewing human communication as step-taking would create a danger of oversimplifying complicated processes. Results of his study show that Dervin's approach can capture data on complexity, as evidenced by participant responses involving coping with complexity of design, the complexity of the study data itself, and the cross-category data analysis required to interpret study data. While this complexity did increase the difficulty of this study, capturing complexity is necessary to better understand the problems faculty experience during complex instructional design. A narrower focus on the study data could eliminate much complexity, but would be likely to misrepresent the true nature of participants' conceptual instructional design experiences.

5.5.7 Iteration

Design *iteration* was identified by looking at participants' actions and questions across their design experience, looking for repeated actions. *Iteration* consisted of repeating a design action to try and correct a problem. Instances of *iteration* are described in terms of the iterative loops observed in the data rather than through direct participant quotes from the interview transcript. The process of *iteration* may not be as apparent in the design context as, for example, a repeated search in Google is for information seeking. Iteration in design may extend across multiple aspects of a design project over a considerable length of time.

Iteration is an important behavior to identify, as this shows that Devin's approach is capable of capturing design iteration, and also that iteration can be identified even in early conceptual design. It is possible that additional design support could reduce the amount if iteration required, improving design efficiency.

This concludes discussion of identified behaviors. The following section discusses big picture questions.

5.6 Big Picture Questions

Big picture findings reflect a variety of concerns and lessons learned. Such lessons may shed light on strategies that can be incorporated in both formal and informal training for instructional designers to help them better approach solution of design problems.

Findings for big picture questions suggest that participants place a high value on question-asking during instructional design. When asked about the most important thing about question-asking during design, responses showed a focus on creating effective learning experiences, appropriately identifying instructional purposes and goals, and evaluating the design. Responses to the question “What is the most important question to ask yourself?” also showed a focus on creating effective learning experiences and identifying the big picture and goals. This is a positive, design-oriented perspective that indicates faculty take their instructional design responsibilities seriously.

However, some responses to the question “What is the most important question to ask yourself?” indicated faculty concern about their own knowledge, abilities, and skills. The 61% of participants who had a response other than ‘None” to the question “Is there a question you wished you’d asked?” indicated needs that were generally fairly straightforward such as determining time and effort required for instructional design, learning how to do a variety of design-related or teaching-related tasks, finding out where to go for help, or improving their own knowledge and abilities. These are areas that could be addressed directly through design support and professional development.

When asked about the effect of question-asking during instructional design (or not) on quality of instruction, all participants agreed that asking questions affects the quality of instruction. Participants see value in asking questions during instructional design. That is a positive result – but it is more than balanced out by the fact that all participants indicated a need for design support or professional development, ranging from locating resources to assistance with multiple aspects of instructional design and teaching.

Opportunities for design support and professional development were identified across all participants and the full range of Sense-making data. Although demographic data for this study does not support specific classification of participants' instructional design expertise, study findings appear to support Merrill and Wilson's (Merrill & Wilson, 2007) findings about as much as 95% of instructional design being performed by designers-by-assignment: those assigned do instructional design without formal training.

The following sections cover use of Dervin's Sense-Making Approach, design mapping, and strengths and limitations of the study.

5.7 Discussion of the Use of Dervin's Sense-Making Approach to Investigate a Small Part of a Larger, Complex Behavior

This may be the first study to use Dervin's Sense-Making to explore a small part of a larger iterative, complex behavior. There were many unknowns. Overall, Dervin's approach worked well to investigate the question-asking behavior of faculty during conceptual instructional design, eliciting interesting and detailed data that satisfied the research objectives. However, there were a few unanticipated difficulties amidst important findings:

1. **Secondary questions**. Future work needs to include a means to better document secondary questions without disrupting the overall flow of the interview. A plan of analysis for secondary questions needs to be developed.

2. **Coding Scope**. The number of unknowns and data complexity combined with the necessary depth of question context resulted in coding of all Sense-Making data. For similar reasons the codebook was maintained fairly flat, with well over 40 codes. This resulted in more work than anticipated. Future work needs to better plan for this.

3. **Iteration**. Design iteration was identified in the study. That was an important finding, providing evidence that Dervin's approach can capture iteration in a non-linear complex behavior. However, identification of iteration is another example of why a high level of detail needs to be maintained in the data, requiring close examination of all Sense-Making data.

4. **Coder Qualifications**. The combination of unexpectedly complex design data, inclusion of many expert/experienced faculty, cross-disciplinary instructional design situations, a wide range of subject matter areas and instructional approaches, and the use of Dervin's approach resulted in a need for more highly qualified coders than originally anticipated. Some experience with general content analysis, user-based research, and instructional design was not adequate to effectively code study data. Cross-disciplinary design experience, familiarity with coding for Dervin's timeline interview technique, and varied instructional design and teaching experience is recommended for coder qualifications in a study of this type. Design-as-a-discipline experience is optimal. The second coder had such experience.

5. **Complex Question Context**. As data was analyzed it became apparent that the relationships between the contextual categories for any given step or question were often less predictable and more complex/interwoven than situations the researcher worked with in previous Sense-Making research. This is important because it reflects the complexity of design and added new levels of complexity to the data analysis.

5.8 Design Mapping

The ad-hoc design mapping analysis suggests that questions asked by participants might be applicable in design domains outside of academia. A total of 93% of the questions for 14 participants were successfully mapped to 47 design domains, 13 from nuclear power. The ad-hoc analysis became more than was expected, providing enlightenment on what's involved in exploration of the concept of design as a discipline. Appendix O discusses the ad-hoc design mapping approach including development, pilot testing, implementation, examples of design mapping, tables of design mapping results, and definitions of the design domains.

This analysis supports the concept of design as a discipline by illustrating similarities in questioning behavior across multiple design disciplines (refer to Figure 23). These results will provide support for future research involving interventions to test questioning techniques from commercial nuclear power to aid designers in other design domains and design education with question-asking during design.

5.9 Strengths of the Study

The strengths of the study included careful attention to reliability and validity, and the strength of the selected methodology for achieving the research objectives.

5.9.1 Reliability

Data on actual behaviors is more accurate and reliable than behaviors predicted by experts or obtained via simulated life situations (B. Dervin, 1983; B. Dervin, et al., 2003b; Nilan & Mundkur, 2007). All data in this study was obtained directly from participants describing their actual conceptual instructional design experiences in their own words. Data is believed to be accurate within the limitations of participants recall and ability to express their design experiences.

Reliability was established through identification of patterns of steps, questions, etc. across a representative sample, obtaining data saturation. Data was obtained in a consistent manner across a range of users. A wide range of steps, questions, question context, design issues, and behavior patterns have been identified both within and across participants design experiences. Many similar responses are visible across the sample, and participants descriptions of their experiences appear to be reasonably comprehensive with no apparent disconnects.

Data is in the respondent's actual words, reducing the potential for researcher misinterpretation of data. To ensure adequate detail, the questionnaire included prompts for clarity and completeness.

One indicator of reliability is if an independent coder can produce reliable judgments of the coding categories that data should fall into. The data should be of adequate detail and accurately reflect the research objectives (Holsti, 1969). Study data is of adequate detail and reflects the research objectives well considering the substantial number of unknowns in the study. An independent coder with appropriate design background was able to produce reliable judgments and reach an average of 94% agreement within two rounds of coding. This is an indicator of category reliability and reproducibility (Holsti, 1969; Weber, 1990).

While 100% data saturation cannot be expected due to the vast number of questions that are possible for complex designing, data saturation has been reached for this study within specified constraints (refer to section 3.5).

Care was taken to ensure that research results are reliable across the instructional design experiences covered in this study.

5.9.2 Validity

Trustworthiness was established primarily through the highly situated nature of Dervin's Sense-Making Approach (B. Dervin, 1983; B. Dervin, et al., 2011). A properly designed questionnaire situates respondents within their own context, a scenario that they have personally experienced. Respondents are not necessarily experts on how to address a specific situation, but they are experts on their own context, questions, problems, and information resource needs. Although there is considerable disagreement about exactly where the line is drawn between natural and contrived interview contexts, a more natural interviewing context improves validity (Speer, 2002).

Dervin's approach is designed to encourage natural discourse through the use of neutral questioning technique interviews (B. Dervin & Dewdney, 1986). The same interview protocol was used for all respondents. Believability was anticipated to be stronger using a 30-minute in-person interview with each respondent rather than electronic data collection or other methods. The complexity of design data, combined with the fact that this was an exploratory study, made the face-to-face interview format very valuable as a means for both the researcher and participant to obtain clarification as needed as the interview progressed.

5.9.2.1 Content Validity

Content validity is generally established by the researcher for descriptive studies, based on plausibility and consistency with other information about the phenomena studied (Holsti, 1969). Data is plausible as it is reasonable and believable. Participants all described conceptual instructional design experiences in which they dealt with newness, information seeking, and problem solving, exhibiting a range of designing behaviors. This is consistent with the researcher's experience and design education, and is supported by the conceptual framework of the study and the literature reviewed.

5.9.2.2 External Validity

Transferability is the generalization of findings to other contexts, similar to the concept of external validity as used by quantitative researchers. Theoretical transference is achieved when the same ideas apply more widely and can be shown to apply in other fields (Suter, 2012).

The design of this study does not offer enough evidence for transferability, but through design mapping of participants' questions to multiple design domains outside of academia, including commercial nuclear power, it is reasonable to suggest that they might be applicable beyond this study. Three design mappers successfully identified similar questions/concerns within their own design disciplines for 93% of the questions asked by the first 14 study participants.

5.10 Strengths of the Methodology

Dervin's approach was a strength of this study because it permits detailed, neutral, open-ended investigation of users' real-life problems and perspectives, providing a sound basis for communications and design (B. Dervin & Dewdney, 1986; B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986). Dervin's work has been applied by Jon Kolko as part of the theoretical framework for his perspective on design synthesis and designers' ability to find meaning in complex situations and solve complex problems (Kolko, 2010c).

Dervin's approach has been applied in many contexts, and has been shown to provide useful data on human behavior, investigating patterns of specific human behaviors and information needs and uses, rather than characteristics of users or information (B. Dervin, 2005; B. Dervin & Dewdney, 1986; B. Dervin, et al., 2003b; B. Dervin & Nilan, 1986; Nilan & Mundkur, 2007; Nilan, Zakaria, Guzman, & Zakaria, 2004; Swain, 1996). In this exploratory study, it was more useful to find out about actual behaviors such as what a user thinks and does, and problems encountered as opposed to describing user or information characteristics, which Dervin and Nilan (1986) also argue is a strength of the approach,

Dervin's Sense-Making Approach permits obtaining detailed data on actual cognitive human behavior in real-life situations, within the limitations of human memory. Recent life situations are selected for investigation to minimize memory issues, typically life experiences within the last six months. For this study, the approach provided insight into user behavior, including questions asked, steps taken, gaps, and information resource needs. Analysis of such specific users' behavior ensures a focus on the actual needs of users rather than developers', vendors', or educators' assumptions about user needs. This approach provides a reasonable basis for designing support systems that truly meet the needs of the user, assuming a representative sample of users that provides adequate data for analysis.

A real strength of Dervin's approach is that it has been applied successfully in many information contexts, and is continuing to expand information seeking and use research into newer areas, such as media research on virtual environments, capturing expert knowledge, knowledge creation and management strategies (do Nascimento Souto, Dervin, & Savolianen, 2012; Linderman, Baker, & Bosacker, 2011; Reinhard & Dervin, 2012). Dervin's approach is a proven means of investigating interdisciplinary information contexts, and is very appropriate for investigation of design cognition.

5.11 Limitations of the Study

The limitations of the study included weaknesses of the Sense-Making approach, concerns about the fact that only a small part of the overall design experience was being investigated, number of variables involved, and the small sample size. This section includes discussion of limitations of the study, including limitations of the methodology and additional study limitations, and, when applicable, how limitations were addressed.

5.11.1 Limitations of the Methodology

Sense-Making can be a time-consuming means of collecting data, as apparent from several of the interviews performed in this study.

Another concern about use of the sense-making technique is the reliance on retrospective verbal data. Ericsson and Simon (1993) discuss concerns about the use of verbal data to validate experience in detail, including

- A loss of immediacy and of data from short term memory
- Retrospective data may be more subjective than concurrent data
- Concurrent verbalization or immediate retrospection provides the most accurate data.
- The ability to recall specific events deteriorates with time

Respondents' recall of their instructional design situations in retrospective interviews may not be perfect. This is a typical limitation of self-reporting data elicitation methods. The potential for poor recall is minimized by allowing respondents to select a significant or recent instructional design experience. Significant or recent experiences are more readily remembered than less significant experiences or experiences that did not occur recently.

Dervin's approach has a proven record of providing rich data and insights on cognitive information seeking activities, and a well-designed and conducted interview will minimize concerns about verbal data. However, as a retrospective interview technique, there are concerns about issues of recall, memory, and loss of detail. Preferably additional methods would be employed in conjunction with interviews, such as document analysis or think-aloud. That will be addressed in future research.

5.11.2 Additional Study Limitations

Study data is exploratory and only covers a small portion of the overall instructional design experience, early conceptual design (the beginning of the design experience). Care must be taken with respect to overlaying design models on data that does not reflect the entire design experience. For some participants there may have been little or no proof of successful design at the time that data was collected. Long term results of participant's instructional design experiences are unknown, and prediction based only on data from early conceptual design is likely to be premature.

This study deals with a small number of variables (12). There are many variables that could contribute to designing and question-asking behavior, known and unknown, and potentially influence the data. This study is not intended to investigate all of the variables associated with the early stages of instructional design, but provides opportunity to investigate the steps, questions, and question context of participants early conceptual instructional design experience.

The small sample size of 18 participants is reasonable for an in-depth exploratory research study, but limits the range and accuracy of results. This is an expected tradeoff. Study results show rich data, ties to research study concepts and literature, and a wide range of design issues. This provides a reasonable level of confidence in the relevance of the interview procedure to the research objectives. While results are not exhaustive, the results are valid and reliable within expectations for a small initial exploratory study.

The study captures design information only from the very beginning of the conceptual instructional design process. Designers may ask interesting questions at any time during the design process, and some design efforts continue for years. While the beginning of the design process can generally be defined as the time when an individual became aware of a need to design, the stages of design may vary considerably across domains, industries, departments, design teams, and designers, for example. The endpoint also varies. Capturing a complete, long-term, complex and iterative design process could take years and encompass a multitude of questions, concerns, risks, issues, designers, and decisions. Unfortunately, this limitation is typical of design research, and illustrates why it is so difficult to research the nature of design and design cognition. Optimally, more of the design process would be investigated. That is expected for future research.

The lack of online courses is also a weakness of the study. Online courses are a different design environment than classroom courses, with specific concerns such as establishing trust and a sense of community, effective and timely asynchronous communication with an audience that may be global, and engaging, supporting and retaining students who may not be fully prepared for independent learning online. The summertime data collection timeframe was a large contributor to the failure to interview faculty who were involved in online courses. Faculty teaching online in summer were generally doing so from home or other off campus locations, and were not available for interviews and/or not inclined to make a special trip to campus to participate. Inclusion of online courses would be expected for future research.

5.12 Recommendations

This section includes recommendations and information on future research.

5.12.1 Recommendations

This section provides recommendations to address concerns identified in the study.

1. This study has identified many questions, concerns, and problems faculty experienced during early conceptual design. Sharing study results may assist faculty developers and others in finding ways to reach and support faculty during instructional design.

2. Primary areas of concern for faculty steps (design actions) and questions/concerns were how to do things, what to do or use during conceptual instructional design, finding appropriate references, and addressing student diversity and cross-disciplinary instructional design and instruction. These areas

can be addressed directly through professional development activities such as seminars and workshops, or through campus resource centers.

3. Design steps and step sequences had no commonalities across participants other than coping with newness. Rather than targeting a process step for support for everyone (for example the searching step during online purchasing), it may be helpful for design support to target specific faculty questions/concerns.
4. The diversity of faculty questions and concerns suggests that surveys of faculty needs could be helpful as a starting point for small group or individual design support. Study results suggest that it may be helpful to survey both experienced and novice faculty.
5. Faculty workshops could provide a platform for sharing best practices and lessons learned. Stories told by faculty to explain the sources of questions and associated challenges and rewards could be helpful.
6. Some participants expressed concern about questions being seen as negative. Care should be taken to encourage asking questions and contacting appropriate faculty resources.
7. International graduate student instructors may need additional training prior to beginning teaching assignments. Design support for international students may need to address special concerns such as English as a second language, cultural differences, and expectations for instructor/student classroom interaction. A needs survey of international graduate student instructors could be helpful to

find out if they are aware of campus support services or need specialized training.

8. A freshman forum may help address retention concerns by educating students about college life and potential careers.
9. Even very experienced faculty had questions about locating necessary resources. It is possible that faculty may not be aware of existing campus resources and contacts. A readily accessible online guide for campus resources could be helpful.
10. Information seeking was the most common designing behavior across the study. Dealing with complexity was also a common thread. There is no easy solution to complex design, but improving information seeking and information management skills could be helpful. Additional design support could reduce anxiety, uncertainty, and the amount if iteration required.

While this research is descriptive, the results may prove useful in generating practical (or prescriptive) recommendations for how questioning can help novice designers and designers by assignment in the early stages of conceptual design. To that end, the next step will be to use the results of this research as a platform for discussion with the Finger Lakes Faculty Development Network, an organization linking people involved in faculty development at campuses in central and western New York. This discussion is anticipated to result in a set of practical recommendations for instructional designers by assignment.

Several publications are expected from this work. Results will be disseminated to the participants, the Finger Lakes Faculty Development Network and the global axiomatic design community, with appropriate measures taken to maintain confidentiality. No personally identifiable information will be shared or published.

5.12.2 Future Research

In addition to the short term future research described above, this research study lays the groundwork for a long-term research agenda involving further investigation of design cognition, design as a discipline, and interventions to test means of supporting and improving the question-asking skills of designers across design disciplines. Future research is anticipated to involve interventions based on techniques from commercial nuclear power to help designers learn to ask better questions during design. Previous small-scale pilot testing of this idea had encouraging results. Support for this research was expressed at the ICAD 2013 conference by design researchers, design educators, and design practitioners.

Future research may also involve development of improved design decision support systems and other tools to aid designers, further exploration of design mapping analysis, and investigation into ways to improve sharing of design practices across design disciplines.

Maintaining a cohort in academia was a new concern for one degree program, and one that turned out to be problematic when co-op or internship schedules disrupted student class attendance. There is an interesting connection between this situation and the design mapping results. Design mapping data pointed out that in nuclear power it is necessary to maintain cohorts for optimal teamwork. This could be a future area of investigation with potential for sharing of best practices.

Asking both converging and diverging questions has been shown to be a helpful question-asking strategy during design (refer to section 2.6.4 and associated references). Comparing the study data to a variety of design models could be an interesting future research project in which the long term success of the designs discussed by participants could be investigated and incorporated.

5.13 Conclusions

Study results support the conceptual framework for the study. Questioning is critical to design, supporting many aspects of design, helping to reduce uncertainty, and leading to new thoughts and creativity. Faculty designing instruction don't always know what to ask, could become overwhelmed, may become complacent, and struggle with the complexity and uncertainty of ill-defined design problems. New domains and complex situations challenged even the most experienced faculty. Several participants indicated that possible negative perceptions of question-asking contributed to reluctance to ask questions. One participant confirmed that expertise does not necessarily transfer well to new domains.

This study helps illuminate cognitive aspects of question-asking during early conceptual instructional design including questions asked, the basis for and sources of questions, designers’ understanding of the uses and values of questions, and how designers act on and resolve their questions. The study identified a wide range of questions, concerns, and problems faculty experienced during early conceptual design.

Recommendations were provided to address identified concerns. A specific recommendation expressed very directly by one participant and less directly by several others is: "As college professors we're not trained enough in instructional design. Most of what we learn is handed down colleague to colleague. I've learned good things at seminars." This reinforces Merrill and Wilson's perspective on designers by assignment (Merrill & Wilson, 2007).

Contributions: As a whole, this study offers two contributions to the fields of instructional design, information science, and design research. First, it provides in-depth exploration of questions asked by faculty designers-by-assignment and expert faculty instructional designers during early conceptual instructional design involving something that is new to them, highlighting problems experienced by faculty. It reaffirms some of the earlier conceptual work about the role of question-asking during design and the needs of instructional designers, identifies needs for improved instructional design support for faculty, and suggests means to aid faculty with instructional design and information seeking.

Second, it adds to our understanding of the concept of design as a discipline by addressing an aspect of design that has received little attention; the existence of commonalities in question-asking behavior during conceptual design across multiple design disciplines. This study provides a detailed example of application of design mapping to identify commonalities in question-asking behavior across multiple design domains. The design mapping ad-hoc analysis suggests that questions asked by participants might be applicable in other design domains. It also provided a partial proof of concept for the idea of design as a discipline and a basis for future research on interventions to aid designers with question-asking.

In a small but critical way, this study demystifies a little bit of the magic of design.

APPENDIX A. GLOSSARY

Attending: Exposing ourselves to the environment, providing an opportunity to encounter a referent, and focusing attention on one thing at a time (Carter, 1980, 1990a, 1990b; Kim, 2003b).

Axiomatic Design: An approach to design developed by Nam P. Suh at MIT and intended to be applicable for all design disciplines. The two axioms of axiomatic design are to maximize the independence of the functional elements and minimize the information, or complexity, in order to guide the design process to the best possible solution for the desired functions (Suh, 1990, 2001, 2005, 2013).

Behavior: The actions or reactions of a person or animal. The manner in which something functions or operates (Houghton Mifflin Company, 2009).

Bimodal Designers: Designers who are capable of both analysis and synthesis (Suh, 2013).

Building: Assembling, constructing, or giving form to something.

Circling Reality: The analysis of a variety of user perspectives to obtain a probabilistic view of reality (B. Dervin, 1983).

Cognition: The study of human intelligence in all its forms, including sensory perception, action, vision, language, memory, and reasoning (Oxman, 1997).

Cognitive load theory: Cognitive load theory suggests that effective instructional material facilitates learning by directing cognitive resources toward activities that are relevant to learning rather than toward preliminaries to learning (Chandler & Sweller, 1991).

Cognitive Science: The field of cognitive science encompasses a range of fields and disciplines that study human thinking, mental processes, memory, intelligence, expertise, motivation, perception, mental representation, and learning (Stolovitch & Keeps, 1999; Davies, 2005), as well as connectivist theories that model thinking using artificial neural networks (Stanford, 2004).

Cognizing: Thinking about the situation and focus of attention to find a way to move (Carter, 1980, 1990a, 1990b; Kim, 2003b).

Collaboration: A joint effort reflecting experiences and viewpoints of persons who intentionally work together to produce a mutually agreed upon end result (Holsapple & Joshi, 2002).

Complacency: A state of satisfaction with the way things are.

Complexity: The existence of many interdependent variables in a given situation. More variables and higher interdependence mean greater complexity and uncertainty. Complexity is subjective (Dorner, 1996), and is often associated with large amounts of information. Also see *Technological Complexity*.

Complex Learning: The integration of knowledge, skills, and attitudes; the coordination of qualitatively different constituent skills; and the transfer of what is learned to daily life or work settings. Students must learn to deal with materials incorporating an enormous number of interacting elements (van Merrienboer & Sweller, 2005).

Conceptual Design: The beginning stage of design, involving preliminary identification and evaluation of user needs, design problems, ideas, options, and solutions, and associated risk, resources, and requirements.

Conceptual Instructional Design: The beginning stage of instructional design when initial direction is defined and preliminary decisions are made. See *Conceptual Design* and *Instructional Design*.

Constructivism: An educational philosophy based on the belief that knowledge is not transmitted: knowledge is actively constructed by the individual based on personal interpretation of experience and past knowledge (Smith & Ragan, 2005).

Containment Structure: A gas-tight shell or other enclosure around a nuclear reactor to confine fission products that otherwise might be released to the atmosphere in the event of an accident. Such enclosures are usually dome-shaped and made of steel-reinforced concrete (U.S. Nuclear Regulatory Commission, 2015a).

Cross-disciplinary: Of, relating to, or involving two or more fields of study. Also see *Interdisciplinary* and *Multidisciplinary*.

Data: Non-contextual representation. For example, the word 'blue' – is it the color blue? The mood? A mispronunciation or misspelling of the word 'blew'? Without context, the meaning can only be guessed at. See also *Information* and *Knowledge*.

Defining: Enumerating the gap(s), goal, potentially useful representations, criteria, and values for something.

Design: The creation of engineered systems that satisfy specific human and societal needs within a context (Suh, 2013).

Design as a Discipline: the idea that there are design commonalities across all areas of design.

Design Cognition: The study of human intelligence during performance of designing behaviors. (See *Designing*).

Design Fixation: Focusing on a solution too early in the design process, potentially increasing risk and the likelihood of poor design outcomes.

Design Mapping: A strategy for revealing a complex of relationships between design representation and thinking, technology, culture, and aesthetic practices, often focused on visualization of data and ideas (Newman, 2013).

Design Research: The focus of design research is to develop a scientific approach to design and expand research on design cognition, including how people learn to design, how to improve design education, and development of techniques to aid designers (Cross, 2007; Hsu & Woon, 1998; Ralf, 2007; Suh, 2013; Xiao, et al., 2011).

Design Science: Design science incorporates design studies and design research, and includes the study-specific issues of questioning behavior and design, and user issues and design.

Designer-by-assignment: Someone who has been tasked with creating instructional materials or methods without having formal training in instructional design (Merrill & Wilson, 2007).

Discipline of Technology: A holistic, cultural approach for dealing with complex technology that focuses on minimizing the potential for disaster, and emphasizes thorough and deep consideration of the match between the product and its use, intense analysis of present and anticipated future conditions of operation, and technical and moral responsibility (Admiral Hyman G. Rickover. M. Aurisicchio & Bracewell, 2013)

Effectiveness: The extent to which a system, action, behavior, or idea leads to improved performance, makes a difficult task easier, or enables accomplishing a task that could not otherwise be accomplished (Krippendorff, 2007).

Evaluation (Evaluating): Determining the value of something (Krathwohl & Smith, 2005).

Expert: An individual with extensive knowledge about a specific topical area, resulting in the ability to correctly predict topic-specific outcomes or actions a high percentage of the time.

Expert Systems: Computer programs that provide answers, solutions, or diagnoses based on available information by following procedures that attempt to duplicate the thought processes and apply the knowledge of an expert in a particular field (Dictionary.com, 2015).

Feedback: Providing status or information to the user about what the user just did. Delayed feedback may increase anxiety or reduce effectiveness.

Flipped Classrooms: The flipped classroom is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussion (Educause Learning Initiative, 2012).

Holistic Models of Instruction: Alternative educational methodologies with the goal of preparing students to meet any challenges they may face in life, typically based on a mixture of disciplines involving philosophy, pedagogy, psychology, and theology. Common foci of holistic education are learning about oneself, developing health relationships and positive social behaviors, social and emotional development, resilience, and the ability to view beauty, experience transcendence, and truth (Forbes & Martin, 2004; Teachnology, 2015).

Human-Computer Interaction (HCI): A discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. This includes how people interact with computers, to what extent computers are or are not developed for successful interaction with human beings, and how to design computers that are safer, easier, quicker and more productive for people to use (Hewett et al., 1996).

Helps: See *Uses*.

Hurts: See *Uses*.

Ill-structured Problems: Any question or matter involving doubt, uncertainty, or difficulty (i.e. problem) that has unclear goals and incomplete information (Dictionary.com, 2015; Voss & Post, 1988).

Informal Learning: education or training in which the learner sets the goals and objective (Cofer, 2000).

Information: Data in context. For example, the data 'blue' when in the sentence 'The sky is blue' provides context to determine the meaning of the word 'blue' (the color as opposed to the mood). See also *Data* and *Knowledge*.

Information Behavior: Information seeking, unintentional, or passive information behaviors such as encountering information, or other purposive behaviors such as avoidance of information or denying the truth of information.

Information Need: A recognition that available data, information, or knowledge is not adequate to satisfy a goal.

Information Seeking: A conscious effort by an individual to acquire information in response to a need or gap in knowledge (Case, 2002; T. D. Wilson & Vickery, 1994). Information seeking can occur during any phase of representing.

Information Technology: The technology involving the development, maintenance, and use of computer systems, software, and networks for the processing and distribution of data (Merriam-Webster Dictionary, 2015).

Institutional Constancy: A concept proposed to explain how organizations can effectively manage large technical systems that involve hazardous materials with potentially significant long-term consequences. Attributes exhibited include careful organization, meticulous program execution, achievement of technical excellence, close management of personnel, and effective communications (Crawford, 1998).

Instructional Design: *"The field of instructional design and technology (also known as instructional technology) encompasses the analysis of learning and performance problems, and the design, development, implementation, evaluation, and management of instructional and non-instructional processes and resources intended to improve learning and performance in a variety of settings, particularly educational institutions and the workplace. Professionals in the field of instructional design and technology often use systematic instructional design procedures and employ instructional media to accomplish their goals. Moreover, in recent years, they have paid increasing attention to non-instructional solutions to some performance problems. Research and theory related to each of the aforementioned areas is also an important part of the field"* (R. A. Reiser, 2012).

Iteration: Repetition of a process or procedure to try to move closer to a goal.

Interdependency: A characteristic of complexity that requires users to attend to many features simultaneously, making it difficult or impossible to undertake only a single action with respect to a system (Dorner, 1996).

Interdisciplinary: Combining or involving two or more fields of study. Also see *Cross-disciplinary* and *Multidisciplinary*.

Intransparence: Having no direct access or no access at all to needed information, requiring decisions to be made based on uncertain information (Dorner, 1996).

Knowledge: The ability to apply information in a way that improves the probability for successful results. For example, given the information "The sky is blue," an individual with knowledge of the relationship between characteristics of the sky and weather would be able to predict that a blue sky means that the weather is likely to be good. See also *Data* and *Information*.

Mental Representation: See *Representing*.

Moving: Doing something about the situation (Carter, 1980, 1990a, 1990b; Kim, 2003b).

Multidisciplinary: Composed of or combining several usually separate branches of learning or fields of expertise (Dictionary.com, 2015). Also see *Cross-disciplinary* and *Interdisciplinary*.

Novice: A beginner in some pursuit which demands skill (Cayne, 1993).

Perception: Conscious understanding of something. Also see *sensory perception*.

Presenting: Making your meaning public for self or others to attend to. Presenting includes performing behaviors necessary to make meaning public, such as speaking, writing, drawing, dancing, unveiling a sculpture, posting a web page, etc. Presenting does not in itself result in direct transfer of meaning, but provides an opportunity for attending, which potentially can initiate additional representing behavior that may result in some level of shared meaning.

Principles of Defense in Depth and Diversity: An approach to designing and operating nuclear facilities that prevents and mitigates accidents that release radiation or hazardous materials. The key is creating multiple independent (diverse) and redundant layers (depth) of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon. Defense in depth includes the use of access controls, physical barriers, redundant and diverse key safety functions, and emergency response measures (U.S. Nuclear Regulatory Commission, 2015a).

Questioning: Inquiring. The range of human behaviors having to do with questions, including but not limited to: 1. self-questioning, 2. asking questions of others (externalized questioning), and 3. having a questioning attitude. Questioning is part of information seeking behavior. Questioning can occur during any phase of representing, information seeking, interacting, or designing.

Questioning Attitude: Individuals avoid complacency and continuously challenge existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action. A value-based, systematic, and iterative use of inquiry as a means to promote valued outcomes of behaviors and help people prevent errors and foster awareness of uncertainty, assumptions, risk factors, and the significance of decisions or actions. A strong questioning attitude should reflect an interest in representing problems, purposive seeking of questions and answers, recognition of the importance of questioning, and awareness of the risks associated with complexity, complacency, and uncertainty (Hubbard, 2009; U.S. Nuclear Regulatory Commission, 2015b).

Questioning Behavior: The range of human actions, reactions, and cognition having to do with questions, including but not limited to: having a questioning attitude, self-questioning (verbally or mentally asking questions of or mentioning concerns to yourself), asking questions of others (externalized questioning), ignoring questions, deferring asking questions, or denying that there are any questions. Factors that may influence questioning behavior include but are not limited to: curiosity, fear, embarrassment, pride, peer pressure, regulatory requirements, anxiety, motivation, denial, and interest. Also see *Questioning Attitude* and *Question Awareness*.

Representing (Representation): The sequence of behaviors that attempts to express meaning to self or others. Refer to section 2.5.1 for an expanded definition and an example.

Safety Culture: Nuclear safety culture is the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment. That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance (International Nuclear Safety Advisory Group, 2002; U.S. Nuclear Regulatory Commission, 2015b).

Selecting: Choosing between options for behaviors or representations, based upon evaluating.

Self-efficacy: An individual's self-judgment about personal capabilities (Bandura, 1977).

Sense-Making Approach: The cognitive and physical behavior of an individual as applied to cognitive movement through time-space (B. Dervin, et al., 2003b).

Sensory Perception: becoming aware of something via the senses. Also see *perception*.

Situatedness (Situationality): The idea that predicting and understanding how people use information and cope with events must be based on the individuals' perceptions of how they see the situations they are in (B. Dervin, et al., 2003b).

Social Learning: Attitude change through learning from direct personal experience, observation, reading or hearing about, or emotional association (Smith & Ragan, 2005).

Social Constructivist Approach: An educational philosophy based on the belief that learning is collaborative with meaning negotiated from multiple perspectives (Smith & Ragan, 2005). Also see *Constructivism*.

Solving: Obtaining an explanation or resolution of something (situation/problem or gap/question).

Systematic Approach: A logical process that helps ensure that performance issues are first evaluated and understood such that design outputs will effectively close the knowledge gaps and address project goals (Oliva, 2015).

Technology: The means of applying the resources of nature to the uses of man. Admiral Hymen G. Rickover (M. Aurisicchio & Bracewell, 2013, p. 292).

Technological Complexity: The existence of many interdependent variables in a given technological system, where more variables and higher interdependence mean greater complexity and uncertainty. Complexity is subjective (Dorner, 1996).

Think-aloud protocols: Verbal research protocols, often applied in user research, in which an observer elicits data by having a subject verbalize his/her thoughts as a task is performed (Nielsen, Clemmensen, & Yssing, 2002).

Timeline Interview Technique: A highly structured neutral questioning interview technique developed by Brenda Dervin. The technique uses a series of open-ended questions to elicit respodents' descriptions of a specific life situation. The technique progresses from event description through details of how respondents saw the event, gaps they had for each event, and if and how the gaps were bridged (B. Dervin, et al., 2003b).

Ubiquitous Computing: an attempt to break away from the current paradigm of desktop computing to provide computational services to a user when and where required. Popularly, the use of small microprocessors to make computers available throughout the physical environment while making them effectively invisible to the user (Dictionary.com, 2015; Salber, Dey, & Abowd, 1998).

Uncertainty: A state in which the order or nature of something is unknown, unpredictable, unreliable, risky, doubtful, undecided, questioned, or not definitively ascertainable.

User: Anyone who uses or may potentially use information, technology, products, processes or services of interest.

User-based: A design/development or research approach that captures and describes behaviors from the user perspective (Nilan & Mundkur, 2007).

User Behavior: Human actions, reactions and cognition with respect to use of information, technology, products, processes, or services of interest.

User-centered: A design/development approach that stresses early focus on users and tasks, empirical measurement, and iterative design (Gould & Lewis, 1985). This approach typically refers to the design of everyday objects, not behavior. This approach is an expert, top-down, aesthetic approach as opposed to a user-based approach that validates the user's reality instead of imposing expert reality on the user.

User-oriented: An even more general term than "user-centered." Most (if not all) user-oriented studies look at characteristics of a user to predict information seeking, use and learning. Simply keeping users in mind is insufficient.

User Studies: A generic term for study of information, technology, product, and service users, associated with a wide range of problem areas and issues.

Uses: The ways that people put answers to their questions to work. Positive uses are called "helps." Negative uses are called "hurts." (B. Dervin & Nilan, 1986).

Wicked Problems: Complex ill-structured problems that are difficult or impossible to solve due to incomplete or contradictory knowledge, a large number of variables (i.e. nearly infinite solution possibilities), no clear point when the problem is definitively solved, and the interconnected nature of these problems with other problems (Buchanan, 1992; Kolko, 2012).

APPENDIX B. PRETEST INTERVIEW PROTOCOL (2005)

IST 820 – Instructional Design Experience Questionnaire

Respondent # ______________________ Interviewer Name ________________________

Date ______ Time: Begin _______ End______

INTRODUCTION & INFORMED CONSENT:

<<Provide respondent with an informed consent form. Continue with this interview only if the respondent wishes to participate in the study and has signed off on the consent form.>>

For an Instructional Design Experience:

"To begin, please think about a specific situation recently when you needed to design an instructional experience for students you had not met, about a topic you were not very familiar with. We want to understand your entire thought process associated with this instructional design experience, including what happened first in your thinking, what you thought and did, or what just happened. You can just choose a specific lesson or topic, it doesn't have to be an entire course design. Remember that we only want to look at what you did before you were in contact with the students.

I'd like to get some details of exactly what happened. Sometimes it helps people to think about this process as if it was in the form of a comic strip – we will look at each piece of what happened, and then we will go back and record your thoughts and feelings about each piece later so we have a complete sequence of pictures of your experience when we are through. I will write down your response on this 3 X 5 card.

So please think back to your first thoughts at the beginning of this instructional design experience:

±1. "Thinking back, what was the very first thing that happened, or the first thoughts that you had in your instructional design experience? "

____

<<Probe for clarity and completeness.>>

±1.Topic "What was the subject matter for this instructional design experience?"

____

<<Probe for clarity and completeness.>>

±1.Topic "Did you have prior experience with this subject matter?"

____

"What happened next?"

SECTION TWO: Cognition

<<*Point to STEP ±1 and ask the respondent to…:*>>

"Please think back to this specific point in this process when <<*read STEP ±1*>>. Now I'd like you to tell me if you had any questions or concerns **related to** the instructional design experience at **THIS** point and by question, I mean anything you wanted to find out about, were confused about, thought your students might be confused about, or were just curious about. This doesn't have to be something that you actually asked about out loud or something that you actually got an answer to. So think back to this first step <<*point to STEP ±1 again*>> and tell me what questions or concerns you had. I will write each one down on a separate 3 X 5 card. Did you have any questions, concerns, or confusion at this point in your instructional design experience?"

"Any other questions at this point in your instructional design experience?"

<< If a STEP has no questions, skip to SECTION THREE B >>

SECTION THREE A: Question loop (one loop per question) STEP: ________

1. "Now we are going to look more closely at each of your questions. In doing this, I will ask you what may appear to be repetitive things but please bear with me and remember that while what I am asking may sound similar, what we are trying to understand is different as you move through your experience and is very important to us. If a thought or feeling is the same as it was earlier, please feel free to say so. First, I'd like you to think to when <<Read STEP>> and you had this question/concern <<Read QUESTION>> and tell me how you thought **AT THAT TIME** that an answer would help you. By help you, I mean what would you have been able to do or understand if you had gotten an answer right then. "

   <<Probe for clarity and completeness – there may be more than one help.>>

2. "And how did getting an answer help you?"

   ____

   <<Chain for clarity and completeness.>>

3. "**AT THAT TIME**, how difficult did it seem to get an answer to your question? If a zero means that it wouldn't have been difficult at all and a ten means that it would have been impossible, how difficult did it seem like it would be to get an answer?"

0	1	2	3	4	5	6	7	8	9	10
|	|	|	|	|	|	|	|	|	|	|
Easy										Impossible

4. "**AT THAT TIME**, how important did it seem to you to get an answer to your question? If a zero means that it wouldn't have been important at all and a ten means that it would have been essential, how important did it seem to you to get an answer?"

0 1 2 3 4 5 6 7 8 9 10

| | | | | | | | | | |

Not Important at all Essential

"What places, resources, or people did you actually try to get an answer for your question **AT THAT TIME**?"

____

<<Probe for clarity and completeness.>>

5. "Did you actually get an answer to this question/concern **AT THAT TIME**? If so, from what source?"

_____ No answer (didn't try or didn't get an answer) *<<Go to #6>>*

_____ Yes, partial answer ________________________ *<<Specify source and go to #7>>*

_____ Yes, complete answer ________________________ *<<Specify source and go to #7>>*

6. "Did you **EVER** get an answer to **THIS** question/concern?"

__ No answer/ Didn't ever get an answer __Didn't ever try to get answer *<<Skip to # 15>>*

__ Yes, partial answer ___________________ *<<Specify source>>* ___________ *<<STEP #>>*

__ Yes, complete answer _________________ <<Specify source>>___________ <<STEP #>>

SECTION THREE B: Helps/Hurts loop (one loop per question, STEP: ______ and one loop per step for steps that have no questions)

7. "**AT THAT TIME**, was there anything specific you can think of that helped you to design your instructional experience and understand the issues involved, such as resources, people, activities, ideas, thoughts, or anything else?"

____________ *<<No other sources? Check this blank and go to next item>>*

First source _______________________________ "What led you to think this was helpful?"

____

"Anything else?"

Second source ______________________ "What led you to think this was helpful?"

____

Third source ______________________ "What led you to think this was helpful?"

8. "**AT THAT TIME**, was there anything specific you can think of that got in the way of your ability to design your instructional experience, or kept you from understanding the issues that might be involved?"

__________ *<<No other sources? Check this blank and go to next item >>*

First source ______________________ "What led you to think that this hurt?"

______________________________________"Anything else?"

Second source ______________________ "What led you to think that this hurt?"

____

Third source ______________________ "What led you to think that this hurt?"

____

SECTION FOUR: Post-situation loop (one loop per instructional design experience)

±N.1 "Now let's jump forward for a minute. Did you actually teach this instructional experience to students?

____

<<Probe for clarity and completeness.>>

±N.2 "Was the material taught in a classroom environment, or an online environment (or both)?"

____

<<Probe for clarity and completeness.>>

±N.3 "Did your students have questions or concerns about the subject matter? If so, what were they?"

____

____

±N.3 “Did you learn anything from this instructional experience that will affect how you approach the design of instructional experiences in the future? This could be actions you take, questions you ask yourself, resources used, etc.?”

SECTION FIVE: ACROSS TIME/SPACE SECTION

“Now we come to the last part of this interview. We need some information about you in order to compare responses from one group of respondents to another for analysis. Please remember that your responses will be kept strictly confidential and all our data will be aggregated across individual respondents. ”

<<Show respondent the STEP cards for the instructional design experience.>>

1. “If you had to point to one thing or condition that helped you with instructional design in this situation, what would that be?”

2. “If you had to point to one thing or condition that hindered your instructional design in this situation, what would that be?”

3. “What questions do you think are most important to ask yourself when designing instruction?”

4. “If a zero means that you are a novice at instructional design and a ten means that you are a real expert at instructional design, would you consider yourself to be a zero or a ten or somewhere in between?”

0 1 2 3 4 5 6 7 8 9 10

| | | | | | | | | | |

Novice Expert

<<Get specific whole number>>

5. “Is there anything else you’d like to tell us about how this instructional design experience has affected you?”

____

____

CLOSING

“This is the end of my interview. Thank you **VERY MUCH** for talking with me. I appreciate your time and participation.”

<<Compute the number of minutes the interview took and mark the total here _______>>

APPENDIX C. PILOT TEST INTERVIEW PROTOCOL (2009)

Instructional Design Experience Questionnaire

INTRODUCTION & INFORMED CONSENT:

<<Provide respondent with an informed consent form. Continue with this interview only if the respondent wishes to participate in the study and has signed off on the consent form.>>

Complete the Administrative Data index card.

******** START AUDIO RECORDING IF PERMISSION IS OBTAINED ********

SECTION ONE: ACTION (STEPS)

To begin, please think about a specific recent or significant situation when you needed to design an instructional experience or instructional materials for any of the following:

- A cross-disciplinary course or lesson
- A topic you were not very familiar with
- To create a type or means of instruction you had not tried previously
-

We will refer to this experience as your "instructional design experience." We want to understand your entire thought process associated with the earliest part of your instructional design experience, when you were just getting started. We want to understand what happened first in your thinking, what you thought and did, or what just happened. You can choose a specific lesson or instructional material -- it does not have to be an entire course design. Remember that we only want to look at the early part of your instructional design experience, when you were first trying to figure out what to do and think about.

We would like to get some details of exactly what happened. Sometimes it helps people to think about this process as if it was in the form of a comic strip in four or five panels – we will look at each piece of what happened, and then we will go back and record your thoughts and feelings about each piece later so we have a complete sequence of pictures of your experience when we are through. I will write down your response on index cards. So please think back to your first thoughts at the very beginning of this instructional design experience, when you first found out that you were going to be designing a course, lesson, or instructional materials: *<< Use the Step One index card. >>*

STEP 1. Thinking back, what was the very first thing that happened, or the first thoughts that you had in your instructional design experience? *<<Prompt for clarity and completeness?>>*

SUBJECT MATTER: What was the subject matter for this instructional design experience?

PLATFORM: Was this subject planned for classroom, online, or both?

PRIOR EXPERIENCE: Did you have prior experience with this subject matter?

CROSS-DISCIPLINARY? Was this for a cross-disciplinary course or topic, one that covers more than one academic discipline?

ADDITIONAL STEPS: << *Use the Step index cards. If you need to add a step in between later, use STEP XA, etc.).* >>

Ask: “What happened next?” << *Prompt for clarity and completeness?* >>

When you are finished with the steps in the ‘comic strip,’ continue with SECTION TWO.

SECTION TWO: COGNITION (QUESTIONS) << *Use the Question index card, 1.1..* >>

For each step in your “comic strip,” starting with STEP 1, please do the following:

Please think back to STEP <<*respondent’s step*>>. Now I would like you to tell me if you had any questions or concerns **related to** the instructional design experience at **THIS** point and by question, I mean anything you wanted to find out about, were confused about, or were just curious about. This doesn’t have to be something that you actually asked about out loud or something that you actually got an answer to. So think back to STEP <<*respondent’s step*>>, and tell me what questions or concerns you had. If a thought or feeling is the same as it was earlier, please feel free to say so.

“Did you have any questions, concerns, or confusion at this point in your instructional design experience?”

“Any other questions at this point in your instructional design experience?”

When you are finished listing questions for each of your steps, continue with SECTION THREE.

SECTION THREE: QUESTION LOOP (one loop per question)

For each STEP, starting with STEP 1, please do the following for each question associated with that step: Write your responses on the question card that you made for that question in Section Two above. Use the backs of the cards or additional cards if necessary. << *Prompt for clarity and completeness?*>>

1. **BASIS:** Now we are going to look more closely at each of your questions. In doing this, I will ask you what may appear to be repetitive things but please bear with me and remember that what we are trying to understand is different as you move through your experience and is very important to us. If a thought or feeling is the same as it was earlier, please feel free to say so. First, I'd like you to think back to STEP <u><<*respondent's step*>></u> when you had this question/concern <<Read QUESTION>> and tell me what led you to think about or ask that question – what the basis for that question was.

2. **SOURCE:** And what was the source of that question? By source, I mean where did you get the question from? For example, your own memory, a reference book, another person, etc.

When you are finished collecting data for each question, continue with SECTION FOUR.

SECTION FOUR: DEMOGRAPHICS

Provide respondent with the Demographics index card to fill out while waiting for question classification to be completed (SECTION FIVE).

SECTION FIVE: COGNITION PART 3 (BIG PICTURE) << *Use Big Picture index card.* >>

1. Is there anything else you would like to share with us about questions to ask during instructional design? The one thing you feel is most important about questions to ask during instructional design, or that you are curious about? << *Prompt for clarity and completeness?*>>

SECTION SEVEN: FEEDBACK

1. If respondent is interested, briefly discuss the possible benefits of questioning. Use the Feedback index card. << *Prompt for clarity and completeness?*>>

   - Jog memory – less chance of forgetting something important.

   - Reduce cognitive load – provides an external reference that compensates for human limitations in mental visualization, supports systematic iteration, helps designers notice new design elements, and helps designers handle different levels of abstraction simultaneously (such as details and big picture concerns).

   - Helps people deal with uncertainty. Questions help to chunk complex design into more easily manageable pieces, and provides pathways to investigate a wide range of options. Exploring options can help to identify potential solutions and concerns, reducing overall uncertainty and risk, including dangers associated with natural human behavior.

- Reduce the potential for design fixation. Design fixation is focusing on a single design solution early in the design process, which can prevent people from identifying multiple solutions and keeping design options open. Design fixation often leads to poor design solutions.

- Give the respondent the option to receive a copy of the study results when available. Document the response on the Feedback index card.

CLOSING: This is the end of the interview. Thank you **VERY MUCH** for talking with me. I appreciate your time and participation. Please do not discuss this study with your fellow faculty until our data collection is complete, in order to avoid biasing our results. You will be notified when data collection is complete. *<< Record interview end time on the Administrative Data index card. >>*

****************** **STOP AUDIO RECORDING** *************************

APPENDIX D. PRETESTING AND PILOT TESTING (2006, 2009)

This section discusses previous initial pretesting and pilot of some of the basic concepts involved in the proposed dissertation research using an earlier version of the interview protocol.

Initial Pretesting

A very small-scale pretest was performed during the spring 2006 semester at Syracuse University by developing a Sense-Making timeline interview protocol and interviewing two iSchool academic professionals who perform instructional design as part of their normal job tasks. The pretest was performed in conjunction with IST 820, Research Conceptualization. The purpose of the pretest was to find out what steps respondents took during the early phases of instructional design, before coming into contact with students, and particularly to find out what questions they asked and what resources were used. The pretest was not meant to provide extensive data, but to provide a basic test of concept.

One respondent was a faculty member with some experience in instructional design, and the other was a graduate student with very little experience in instructional design. The faculty member talked about using a mental laundry list to compare prior instructional experiences with what he now needed to teach, looking at what had or had not worked in the past, developing a thematic metaphor for the subject matter, and stressing use of visualization in presentations. The graduate student discussed an example involving syllabus design. She was largely focused on what general topics needed to be taught, and problems associated with locating potential content on the

Internet. The graduate student was concerned more with finding case study and other content examples to compliment a specific textbook than on student-specific issues, and had not really considered what problems students might have with the material.

Neither respondent was informed of the purpose of the interview until after the interview was complete. At that time, the concept of representing was explained to the respondent, and we generally discussed representing behavior, instructional design, and associated questioning behavior. The faculty member was very interested in this. The novice graduate student had not thought of most of the questioning issues, but thought that knowing more about what to ask could be helpful, as she was totally lost during most of the instructional design situation that she shared.

Both interviews provided information on questions and design criteria for issues such as what to teach, how to present material, presentation length, appropriateness of content, use of visualizations, what information resources to use, etc. However, neither interview provided information on whether respondents attempted to identify potential areas of student difficulty, so, during the post-interview general discussion, each respondent was asked whether they made an effort to identify content areas where students might have difficulty or ask questions. The faculty member considered his presentation to be for awareness of issues rather than education, and was not very concerned with questions that the audience may have. The novice respondent did not consider any audience-specific issues, other than whether the general technical content of the course was appropriate for the undergraduate audience. This interaction was the starting point for my interest in faculty perceptions of new questions that they had not thought to ask during instructional design.

Overall, the data from these interviews fit what was generally expected. The more experienced respondent had a more systematic approach, used a wider range of resources, considered what had and hadn't worked in the past (accessing existing representations), and pieced together new representations based on parts of prior representations and what was being learned about the new subject matter. It was apparent that the more experienced respondent had thought about the mental processes involved in at least some aspects of instructional design, and had a list of some questions to ask of self or others along the way. This reflects a systematic approach to design. The novice respondent was entirely focused on what subject matter could be used, with very little consideration of other aspects of instructional design, and almost no other questions to ask. It was also noticeable that the more experienced respondent considered some audience-specific issues, especially presentational creativity and maintaining the attention of the audience.

Pilot Testing

Two pilot testing run-throughs of the interview protocol were previously completed using the 2009 interview protocol. Pilot testing was performed with members of the Finger Lakes Faculty Development Network and other interested individuals who are not part of the potential respondent pool. While these individuals were generally aware of the intent of the research, which could potentially bias results somewhat, the purpose of the pilot testing was to refine the data collection instrument and verify that results are reasonable. Pilot testing results will not be generalized or published, and are not considered to be research data.

Results were encouraging. Minimal changes were required to the interview protocol, mostly to more clearly define question context or clarify certain questions asked of the respondent. The revised interview protocol reflects those changes and additional changes resulting from revision of this dissertation proposal. The data obtained was reasonable. Actual questions were collected, and the respondents' perceptions of the new questions and explanations of the benefits of questioning during design reflected interest in the 'questioning as a human performance tool' techniques used during the interview. There was some confusion about one interview question where the respondent was so focused on student needs that she had difficulty switching over to discussion of her own needs as an instructional designer. This was resolved by rewording the interview question to stress that although student needs were extremely important to consider during instructional design, and she was doing a very good job of investigating student needs, her needs as an instructional designer were of interest for this question.

One limitation of the initial pilot test run-through was that the digital clipboard that will be used for data collection was not yet available. This did not change the nature of the interview. The digital clipboard should be available for actual data collection.

Conclusion: Pretesting and Pilot Testing

Although the pretest and initial pilot tests were performed in 2006 and 2009, the interview protocol used was very similar to the current protocol, supporting similar concepts. The pretest and initial pilot test data supports the general expectations for data collection for the proposed research study, within limitations of such small samples.

APPENDIX E. REVISED INTERVIEW PROTOCOL (2014)

Instructional Design Experience Questionnaire (Revised 3/12/14)

NOTE: <<indicates a prompt>> and "indicates interviewer spoken content"

INTRODUCTION & INFORMED CONSENT:

<<*Provide respondent with an informed consent form. Continue this interview only if the respondent wishes to participate in the study and has signed off on the consent form.*>>

Complete the Administrative Data index card. (date, start time, respondent, interviewer)

******** START AUDIO RECORDING IF PERMISSION IS OBTAINED ********

SECTION ONE: OVERVIEW and ACTION (STEPS)

"To begin, please think about a specific recent situation when you needed to design an instructional experience or instructional materials for any of the following:

- A cross-disciplinary course or lesson
- A topic you were not very familiar with
- To create a type or means of instruction you had not tried previously

We will refer to this experience as your "instructional design experience." We want to understand your entire thought process associated with the earliest part of your instructional design experience, when you were just getting started. We want to understand what happened first in your thinking, what you thought and did, or what just happened. You can choose a specific lesson or instructional material -- it does not have to be an entire course design. Remember that we only want to look at the early part of your instructional design experience, when you were first trying to figure out what to do and think about.

We would like to get some details of exactly what happened. Sometimes it helps people to think about this process as if it was in the form of a comic strip in four or five panels – we will look at each piece of what happened, and then we will go back and record your thoughts and feelings about each piece later so we have a complete sequence of pictures of your experience when we are through. I will write down your response on index cards. So please think back to your first thoughts at the very beginning of this instructional design experience, when you first found out that you were going to be designing a course, lesson, or instructional materials:"

STEP 1. "Thinking back, what was the very first thing that happened, or the first thoughts that you had in your instructional design experience? " << *Use the Step One index card.* >> *<<Prompt for clarity/completeness?>>*

SUBJECT MATTER: "What was the subject matter for this instructional design experience?"

PLATFORM: "Was this subject planned for classroom, online, or both?"

PRIOR EXPERIENCE: "What prior experience did you have with this subject matter?"

CROSS-DISCIPLINARY? "Was this for a cross-disciplinary course or topic, one that covers more than one academic discipline?"

ADDITIONAL STEPS: **Ask:** "What happened next?" << *Prompt for clarity and completeness?* >> << *Use Step index cards. To add a step later, use STEP XA, etc.).* >>

When you are finished with the steps in the 'comic strip,' continue with SECTION TWO.

SECTION TWO: COGNITION (QUESTIONS)

<< Use the Question index card, 1.1… >> (One question per card)

For each step in your "comic strip," starting with STEP 1, please do the following:

"Please think back to STEP *<<respondent's step>>*. Now I would like you to tell me if you had any questions or concerns **related to** the instructional design experience at **THIS** point and by question, I mean anything you wanted to find out about, were confused about, or were just curious about. This doesn't have to be something that you actually asked about out loud or that you actually got an answer to. So think back to STEP *<<respondent's step>>*, and tell me what questions or concerns you had. If a thought or feeling is the same as it was earlier, please say so."

"Did you have any questions, concerns, or confusion at this point in your instructional design experience?"

"Any other questions at this point in your instructional design experience?"

When you are finished listing questions for each of your steps, continue with SECTION THREE.

SECTION THREE: QUESTION LOOP (one loop per question)

For each STEP, starting with STEP 1, please do the following for each question associated with that step: Write your responses on the question card you made for that question in Section Two above. Use more cards if needed. << *Prompt for clarity and completeness?*>>

A. BASIS: "Now we'll look more closely at each of your questions. I will ask you what may appear to be repetitive things, but please bear with me and remember that what we are trying to understand is different as you move through your experience and is very important to us. If a thought or feeling is the same as it was earlier, please say so. First, I'd like you to think back to STEP *<<respondent's step>>* when you had this question/concern <<Read QUESTION>> and tell me what led you to think about or ask that question – what the basis for that question was."

B. HELPS: "When you had this question/concern <<Read QUESTION>> "AT THAT TIME, was there anything specific you can think of that helped you to design your instructional experience and understand the issues involved, such as resources, people, activities, ideas, thoughts, or anything else?"

C. HURTS: "When you had this question/concern <<Read QUESTION>> AT THAT TIME, was there anything specific you can think of that got in the way of your ability to design your instructional experience, or kept you from understanding the issues that might be involved?"

D. ANSWER: "Did you actually get an answer to this question/concern AT THAT TIME? If so, from what source? How did the answer help?" *<<(No) OR (Yes – Partial/Complete, Source, how helped?)>>*

"Did you **EVER** get an answer to **THIS** question/concern?"
<<(No – didn't ever or didn't try?) OR (Yes – Partial/Complete, Source, how helped?)>>

E. SOURCE: "And what was the source of that question? By source, I mean where did you get the question from? For example, your own memory, a reference book, another person, the Internet, etc."

When you are finished collecting data for each question, continue with SECTION FOUR.

SECTION FOUR: DEMOGRAPHICS

Provide respondent with the Demographics index card to fill out

(age range, ethnic background, experience level, years as instructional designer, gender))

SECTION FIVE: COGNITION (BIG PICTURE)
<< Use Big Picture index card. >> << Prompt for clarity and completeness?>>

1. "Is there one thing you feel is most important about questions to ask during instructional design, or something you are curious about?"
2. "Is there a question you wish you had asked?"
3. "What questions do you think are most important to ask yourself when designing instruction?"
4. "How does it make a difference in the quality of instruction as compared to when you overlook or leave out questioning?"
5. "Is there anything else you'd like to tell us about how this instructional design experience has affected you?"

SECTION SIX: POST-INTERVIEW FEEDBACK

1. If respondent is interested, and time allow, briefly discuss the possible benefits of questioning. Use the Feedback index card. << *Prompt for clarity and completeness?*>>
   - Jog memory – less chance of forgetting something important
   - Reduce cognitive load – provides an external reference that compensates for human limitations in mental visualization, supports systematic iteration, helps designers notice new design elements, and helps designers handle different levels of abstraction simultaneously (such as details and big picture concerns).
   - Helps people deal with uncertainty. Questions help to chunk complex design into more easily manageable pieces, and provides pathways to investigate a wide range of options. Exploring options can help to identify potential solutions and concerns, reducing overall uncertainty.
   - Reduce the potential for design fixation. Design fixation is focusing on a single design solution early in the design process, which can prevent people from identifying multiple solutions and keeping design options open. Design fixation often leads to poor design solutions.
2. Give the respondent the option to receive a copy of the study results when available. Document the response on the Feedback index card.

CLOSING:

"This is the end of the interview. Thank you **VERY MUCH** for talking with me. I appreciate your time and participation. Please do not discuss this study with your fellow faculty until our data collection is complete, in order to avoid biasing our results. You will be notified when data collection is complete." << *Record interview end time on the Administrative Data index card.* >>****************** **STOP AUDIO RECORDING** *************************

APPENDIX F. RECRUITMENT LETTER

Date: ____

Subject Name: ____

College/Department: ____

Re: Research Study – Exploring How Faculty Design New Materials and Experiences for Teaching and Learning

Dear Professor ____,

As a doctoral candidate at the Syracuse University School of Information Studies with expertise in design, I am exploring how faculty design new materials for teaching and learning. We would like to talk to you about a recent or significant situation when you needed to design instructional materials or an instructional experience for any of the following:

- A cross-disciplinary course or lesson
- A topic you were not very familiar with
- To create a type or means of instruction you had not tried previously

This research study is being performed in conjunction with the Finger Lakes Faculty Development Network, and is sponsored at Syracuse University by my advisor, Professor Marilyn Arnone.

You might be a good candidate for participation in this study if you have recent experience creating instructional materials/experiences for students in ____. Participation will involve a single 30-minute in-person interview, which can be conducted in your office or other convenient on-campus location. We simply want your recollections and thoughts about an instructional design experience. There are no right or wrong answers and your answers will be kept strictly confidential. No personally identifiable data will be shared or published in any form. Risks are minimal and are outweighed by potential benefits.

The data collected during this study will be used to help us understand the needs of faculty who design new materials and experiences for teaching and learning, from the perspective of the user. This information will help us support cross-disciplinary instructional design and future professional development for faculty. By taking part in the research you may also have the opportunity to gain knowledge of useful instructional design techniques and share expertise.

Participation in this study is entirely voluntary, but we would really like your input to get a good representation of faculty experiences. If you decide not to contact us about the study or not to participate, you will not be penalized in any way.

If you may be interested in participating in this study, or have questions, please email Sue Rothwell at ########## or call her at ##########.

Sincerely,

Susan L. Rothwell

APPENDIX G. INFORMED CONSENT FORM

Informed Consent Form for the Instructional Design Experiences Study

We are inviting you to participate in a research study about faculty perceptions of instructional design experiences. Involvement in the study is voluntary, so you may choose to participate or not. This sheet explains the study, which is being done as a cross-university research project with the Finger Lakes Faculty Development Network. Please take whatever time you need to read this sheet, and feel free to ask questions about the research if you have any. We will be happy to explain anything in detail if you wish.

We are interested in learning more about a specific recent or significant situation when you needed to design an instructional experience or instructional materials for any of the following:

- A cross-disciplinary course or lesson
- A topic you were not very familiar with
- To create a type or means of instruction you had not tried previously

We will refer to this experience as your "instructional design experience." During this research study we will ask you to spend about 30 minutes talking to us in detail about your instructional design experience. The researcher will write down your responses as the interview proceeds. With your permission, we will audio record this interview. If you do not want to be audio recorded, you may refuse to be audio recorded without penalty or loss of benefits.

Your participation in this research study is completely voluntary but we **really** need **YOUR** input to get a good representation of people's experiences. Very little research has been done on instructional design from the user's perspective, and we really want to learn about your experiences. You may refuse to answer any question without penalty or loss of benefits. You can change your mind at any time and withdraw from this study without penalty or loss of benefits at any time up until the study has ended. Contact the researcher if you wish to withdraw from the study. If you do not want to take part, you have the right to refuse to take part without penalty or loss of benefits.

This study is **NOT** intended **IN ANY WAY** to be an evaluation of your behavior. We simply want your recollections and thoughts about an instructional design experience. There are no right or wrong answers. Your answers will be kept **strictly confidential**. A number will be assigned to your responses, and only the researcher will have the key to indicate which number belongs to which participant. We will not record your name on your data. Names and other personally identifying information will be removed from the data and will not be shared with the Finger Lakes Faculty Development Network or anyone else, or published in any form. Results will be combined with answers obtained from other people in our study so that what will appear in our results will be overall averages or trends of what many people think or believe.

The benefit of this research is that you will be helping us to understand the needs of faculty who perform instructional design, from the perspective of the user. This information will help us support cross-disciplinary instructional design and future professional development. By taking part in this research study, you may also have the opportunity to gain knowledge of useful instructional design techniques and share expertise. We cannot guarantee that you will personally experience benefits from participating in this study. Others may benefit in the future from what we learn from this study.

The risks to you of participating in this study are minimal. It is possible that you could feel fatigued from the interview, or that a question could make you psychologically uncomfortable. This risk will be minimized by allowing you to refuse to answer any question or to discontinue the interview. You may be uncomfortable about being recorded. This risk will be minimized by allowing you to refuse to be recorded or discontinue recording at any time. Audio recordings will be destroyed when the study is complete. You may be concerned about confidentiality and privacy. As explained above, code numbers will be used for the data instead of names, no personally identifiable information will be published or shared with anyone, and only the researcher will have access to the key that connects respondents with the data. The key will be securely stored in a locked file cabinet in the researcher's home office. Data files will be kept on the researcher's password-protected personal computer and on backup disks in a locked file cabinet in the researcher's home office. There may be other risks that we cannot predict.

If you have any questions, concerns, or complaints about the research, contact the faculty advisor/primary investigator Professor Marilyn Arnone or myself, Sue Rothwell. Contact information is provided at the end of this form. If you have any questions about your rights as a research participant, you have questions, concerns, or complaints that you wish to address to someone other than the investigator, or if you cannot reach the investigator, contact the Syracuse University Institutional Review Board at ###########.

All of my questions have been answered, I am over the age of 18 and I wish to participate in this research study. I have received a copy of this consent form.

____ ____________________________

Signature of participant Date

____

Printed name of participant

____ ____________________________

Signature of researcher Date

____

Printed name of researcher

Contact Information

Researcher:
Susan L. Rothwell
###############

Faculty Advisor and
Primary Investigator:
Professor Marilyn Arnone
#################

Syracuse University Office of
Research and Integrity Protections
################

APPENDIX H. INSTRUCTIONS FOR INTERCODER RELIABILITY TEST RUN

INSTRUCTIONS FOR INTERCODER RELIABILITY TEST RUN

* Please track your time on task for this round to the nearest half hour, not including time initially spent familiarizing yourself with the codebook.

1. This is a work in progress. Feel free to suggest revisions to the codebook.
2. Code on the INTERCODING DATA worksheet in the columns labeled 'Code YOURNAME'
3. Note that the big-picture items in columns AF through AJ are to be coded as a single set using multiple codes.
4. Code for the primary category or categories for each cell. A single category is preferred if reasonably possible, but do not leave anything uncoded.
5. Any comments, points of confusion, questions, suggestions, etc. should be communicated in the Comments column.
6. The Resolution column will be used to work out coding conflicts. Do not write anything in the resolution column as you code this first round.
7. The raw data is provided for reference in case something gets goofed up on the Intercoding Data worksheet.
8. Please do not change the color coding of your columns or I will get confused. If I have assigned you a color that is unworkable or unbearable, please let me know immediately so we can work something out as soon as possible.
9. When you are done, report your time on task in the field provided below, rename your file to Rothwell_Intercoder_Round#_YOURNAME_Date_DONE and return it to me at slrothwe@syr.edu

TIME ON TASK: _______

APPENDIX I. CODEBOOK FOR INTERCODER RELIABILITY TEST RUN

Code Name	Code	Definition	Examples
Who	Who	People, Self	Peers, students, users, customers, employers, teachers or groups, etc. are mentioned
What	What	An object, idea, etc.	I knew what I wanted to do.
Where	Where	Location	Class, lab, field location, studio, manufacturing plant
When	When	Associated with time	At end of course, after students complained, before semester started
Why	Why	The basis for what is being discussed	(expected to be in the Basis for Question field)
How	How	The means (actual or postulated) of creating or accomplishing something	I learned to create one.
Barrier	B	A short or long term stopping point that prevents forward motion through a situation	(No coding for this yet)
Attending to Newness	NEW	Realizing the need for or existence of something new	I wanted to try a new approach.
Information Need	IN	Realizing there is a lack of information or uncertainty about information	I was lacking knowledge.
Seeking	IS	Purposely identifying additional gaps or areas of concern within the overall situation	Questioning, finding new or useful information, searching, learning, and creating or modifying representations as part of the building blocks toward a set of potential solutions

Code Name	Code	Definition	Examples
Design Iteration	DI	Looping of the design process	The answer to a question is another question, resulting in backtracking and trying again.
Decision Making	DM	(in progress)	I chose a textbook for the course.
Identifying a Problem	IP	(in progress)	(in progress)
Information Accuracy	IA+, IA-	Accurate information is IA+, inaccuracies are IA-	(in progress)
Information Relevance	IRV	(in progress)	(in progress)
Design Strategy (Process, Self)	DS	Determining or applying a specific approach to designing	I always start with this for hands-on learning. Sequence of assembly is determined by fit.
Complexity	CX	(in progress)	(in progress)
Trusting	TR	TR+ if trust is gained, TR- if trust is lost	Teachers trust students or vice-versa
Simulation or Pilot	TST	Use of a simulation, model, prototype, pilot test, or other means to test out a design concept.	(in progress)
Time Constraints	T	(in progress)	Not enough time to teach this topic.
Defining	DEF	(in progress)	(in progress)
Creating	CR	Developing something that is new or different, or necessary and not otherwise available	I developed the course. Students made drawings.
Evaluating	EV	Assigning Value to something	(in progress)

Code Name	Code	Definition	Examples
Field Dependence /Indepen-dence	FD, FI	Field dependence is global, big-picture thinking. Field independence is thinking at the detail level to break a situation into component parts.	(in progress)
Parallel Thinking	PT	The ability to process multiple distinct trains of thought at the same time.	Details and big picture, or multiple design options, considered in what is effectively a simultaneous manner.
Motivation	M+, M-	Internal, external, or self-motivation (things that help for +, things that hurt are -)	Pride in accomplishments, excitement about teaching or designing
Fear of Failure – Students (students, high school, family)	FST	Concern that your students will fail or have other negative consequences, or that there could be negative consequences for their families or high schools	Fear of student failure expressed by instructor or students
Fear of Failure - Self	FSF	Concern about failing with respect to the design, design process, related skills, associated social contexts, etc.	Fear of opinion of others, lack of knowledge/skills, negative consequences for self
Fear of Failure - Community	FCE	Concern that there will be negative effects on the community or local economy.	Fear of opinion of others, lack of knowledge/skills, negative consequences for community
Learning	L+, L-	The act, process, or experience of gaining knowledge or skill.	Increasing knowledge or skill about a process, technology, values, etc.

Code Name	Code	Definition	Examples
Human Resources	HR	Reference to human resources used during the design process for the purpose of providing information.	Contacting other people for information or assistance locating information, such as a department chair or subject matter expert.
Information Resources	IR+, IR-	Reference to information resources used during design process	The Internet, the web, reference materials, my iPod, blueprints, etc.
Technology Resources	TRS, TRS-	Hardware, software, networks or applications used during design process	Computers, lab equipment, Google, PowerPoint, video camera, tools. Problems with a technology resource may be coded as a negative.
Users	UI, UC	Involving users in the design process, and/or testing a design, or focusing on user characteristics. UI - involving users, or UC - characteristics of users)	User testing, obtaining user feedback, testing a design.
Emotions	E+, E-	Emotions experienced by a respondent that are not covered by any other coding category.	Being anxious or excited about the design process, being worried that something might go wrong.
Other	O	Anything not covered by other codes but deemed important by the coder.	Use the comments field in your data coding spreadsheet to suggest new codes.
Not Asked/Not Applicable	999	This question is not applicable for coding.	999
No Response Given	999R	The question was asked, but the respondent did not provide an answer to this question.	999R

APPENDIX J. INSTRUCTIONS FOR INTERCODER RELIABILITY

PHASE 1

INSTRUCTIONS

We're trying a new approach: coding Source, How Answer Helped, Hurts, and Helps first. Many of these are straightforward. Some will require careful review of all associated context. I have coded lines 6 and 7 as examples, highlighted in yellow. Code for the main idea first, with no more than two codes per item if possible. Doing this portion of the data first will minimize the number of codes to work with, and give you a chance to become familiar with things before we move on to coding the remaining data. The raw data is provided for your reference in case something gets goofed up in the data you are coding.

If you are stuck on an item, highlight it in purple, explain why you are stuck, and move on. I have provided an example of that in line 7. (999 means no data was provided and no coding response is required). If you don't understand my definition of a code, please let me know so I can try and improve it ASAP.

Remember that the column headings for the data come directly from the interview questions for Dervin's timeline interview technique. A copy of the interview protocol is provided on the CONTEXT tab for your reference. All data has been included within the constraints of confidentiality. When possible, try to code based only on the contents of that individual cell. In general, context for a cell is provided within that same row, but sometimes a feel for the overall impact of the design experience on a participant is required to code a specific item (looking at everything for that participant). FYI, I found it easiest to start with Source (of question) and work backwards to Helps).

CODEBOOK - Source, How Answer Helped, Hurts, Helps	
GUIDANCE	
SELF	Myself, me, my own experience provided guidance
PEER	Guidance from or observation of colleagues, specific peers, program or project manager, department chair, etc.
ADMIN	General administrative or institutional guidance, program level or

	higher
EMP	Guidance from external employers/industry
MFV	Guidance from external manufacturer or vendor
GOT HELP	External help from other people, groups, or agencies was received
EDU	Guidance from my education
REF	References, hardcopy or digital
HOW	Guidance on how to do something
WHAT	Guidance on what to use or do, including how much of something to use
DESIGN PATH	
WORSE	An answer or action made the design situation worse
STOP	Progress on part or all designing was halted due to an unexpected problem
UND	Designer obtained a better understanding of the problem or situation (not specific to completing a task or obtaining assistance)
DIR	Participant had more direction toward a goal, is on track
ONI-	Ongoing design situation or issue that has validated the initial concern or question. An important, definite, specific problem remains to be addressed, and the designer is still concerned.
ONI	Ongoing design situation or issue that may or does still need improvement (often typical if a question has only been partially answered).
SOLVED	The answer to the question led to a definite solution to the problem
PROBLEMS	
CSELF	Concern about self
CSTU	Concern about students, current or future
EQUIP	Problems with equipment computers, lab equipment, etc.
CONTENT	Problems with instructional content, including provided textbooks

WHEN	
TIME	Availability of time is a concern
TIME+	Increase in time available
CONFIDENCE, MOTIVATION, and LEARNING	
SE	Self-efficacy. One's belief in one's ability to succeed in specific situations. (Albert Bandura)
SE-	Designer is moving toward increased self-efficacy, but still acknowledges anxiety or fear with respect to his or her design situation
MOT	Motivational factor for the participant - happenings or feelings that keep the participant interested in continuing the design process
DOING	Learned it as I was doing it during the design experience
STUF	Designer/instructor received feedback from students on part or all of the new design or on past design
SLRN	Evidence that students are learning/succeeding
LLBA	Lesson learned by the participant, best practice, advice for other designers/instructors
OTHER	
N/E	Novice/expert divide: coping with the novice/expert divide, trying to take the perspective of a novice, etc. Also known as the expert effect.
REALITY	The reality of the facts, project, activity, etc. Includes workload concerns. A statement that means that's just the way things are.

APPENDIX K. CODEBOOK FOR INTERCODER RELIABILITY PHASE 2

CODEBOOK 102914 Rev. 2				
CODE	**CODE NAME**	**CODE**	**DEFINITION**	**EXAMPLES**
HOW	How	HOW	Needing or receiving guidance on how to do something	How will the new material fit in with what I've been doing?
WHAT	What	REF	Guidance, needs, or insight for what to use or do, including how much of something to use (WHAT). References, hardcopy or digital (REF).	Knowing the most common disease cases that would be tested for (WHAT). Book, dissertations, articles. Go on the Internet and find reliable sites.(REF)
WHEN	When	TIME, TIME+	Available time as a factor (TIME). Increase in time available (TIME+).	Not a good use of time (TIME). It would free up my time from preparing a lecture. (TIME+)
WHERE	Where	WHERE	Concern about locating a source for something	Where can I learn this?
WHO	Who (general)	WHO	Expressing a need related to locating or learning about specific individuals	[Question/Concern] Ask contact at another university for contacts in other related labs
	Students	STU	Students, student background, learning styles, level of skill or experience, demographics	We have a very diverse body of students

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
WHO (continued)	Myself	SELF, EDU	Myself, me, my own experience or education (EDU) provided guidance	Knowing relationships are important. Personal philosophy. My own experiences in grad school.
	Peers	PEER	Guidance from, discussion with, or observation of colleagues, specific peers, program or project manager, department chair, etc. Targets design support rather than emotional support/motivation	Talking to colleague who taught a similar course about what they did.
	Administra-tive Guidance or Issues	ADMIN	General administrative or institutional guidance, program level or higher. Policies, legal requirements, etc.	Curriculum committee. The program goal of retention in industry three years after graduation.
	Employers/ Industry (general)	EMP	Guidance from external employers/industry	[The basis for the question is] turnaround in industry. Staffing issues are chronic.

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
WHO (continued)	Manufacturers and Vendors (technical, equipment or facility support)	MFV	Guidance from or discussion with external manufacturer or vendor, generally to address equipment-specific issues.	[Helps were} Ideas, textbook, equipment manufacturers.
	Unspecified Sources of Human Help	GOT HELP	External help from other people, groups, or agencies was received. Use this when none of the other help-related codes apply.	Found someone to help.
	Teamwork	TEAM	Working in depth with others to develop a new course, curriculum, etc.	Worked with other professor to review textbooks, choose text, and suggest lab work.
PROBLEMS/ CONCERNS	Concern for Myself	CSELF	Concern about self	The critique process exposes a vulnerability. Teachers are expected to know all this, but we're constantly learning.
	Concern for Students	CSTU	Concern about students, current or future	Didn't want to slam students or ask too much
	Equipment, Facilities and Technology Problems	EQUIP	Problems with equipment computers, lab equipment, etc.	What lab equipment is available to me?

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
PROBLEMS/ CONCERNS (continued)	Instructional Content	CONTENT	Problems with instructional content, including provided textbooks	Wanted a text with good figures in it and good and reliable animations.
	Sequencing of Information or Activities	SEQ	Sequencing concern	Other class provides background for my class, but lecture class was after my lab class!
	Accessing Information	ACCESS	Concern about access to information, including the Internet	How to access things on the Internet, what type of timeframe they [students] would have for that.
	Interdisciplinary or Cross-Disciplinary Issues	INTER	Concern about interdisci-plinary issues	How to incorporate interdisciplinary lesson development?
	Evaluation	EVAL	Evaluation concern	How to evaluate students?

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
SELF-EFFICACY, MOTIVATION and LEARNING	Self-efficacy	SE	Self-efficacy. One's belief in one's ability to succeed in specific situations. (Albert Bandura) Includes accomplishments such as succeeding in learning something necessary for designing. Designer may be increasing self-efficacy, but still acknowledges anxiety or fear with respect to his or her design situation	My courage came from knowing this was going to be small enough that with my regular budget I can handle it. Anxiety was reduced after discussion with colleague.
	Motivation	MOT	Motivational factor for the participant - happenings or feelings that keep the participant interested in continuing the design process	I was excited to teach it.
	Doing the Design	DOING	Learned it as I was doing (piloting) the design during the design experience	Tried out machining, etc. And learned.
	Student Feedback	STUF	Designer/instructor received feedback from students on part or all of the new design or on past design. Includes pilot class.	Looked at last years' student reviews. I thought students wouldn't like one thing, but reviews liked it. Surprise!

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
SELF-EFFICACY, MOTIVATION and LEARNING (continued)	Student Learning and Success	SLRN	Evidence that students are learning and succeeding	Students continue to learn and inquire, sense shortcomings and address them or ask for help rather than hiding things.
	Lessons Learned, Best Practices and Advice	LLBA	Lesson learned by the participant, best practice, advice for other designers and instructors	Until you've been through it once you're not very good at answering that question.
DESIGNING	Realizing a Need for or Encounter-ing Something New	NEW	Course, associated design activity, design context, instructional content or method, etc. is new to designer.	Build an inventory list of skills and employable outcomes. This is what was different for me, working with these employers. The employers are the content experts for new technologies, the innovators, and have new knowledge that we don't have.
	Worsening Design Situation	WORSE	An answer or action made the design situation worse	It didn't help - made things more difficult.

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
DESIGNING (continued)	Design is Stopped	STOP	Progress on part or all of the design was halted due to an unexpected problem	We didn't have a facility. No room, no space, no program!
	Understanding Design	UND	Designer obtained a better understanding of the problem or situation (not specific to completing a task or obtaining assistance). Includes thinking through alternatives.	Asking questions improved my understanding.
	Direction of Design	DIR	Participant had more direction toward a goal, is on track	Helped to keep me on track going ahead with new design and activities.
	External Representation of Design	EXT REP	Creating an external representation to aid with the design process at the brainstorming level, such as a sketch, diagram, list/outline	I made a SWOT diagram (Strengths, Weaknesses, Opportunities, Threats)

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
DESIGNING (continued)	Designing Real Life Project Based Learning Experiences	DESPROJ, HANDS ON, CREATIVE	Creating a realistic design project, realistic hands-on project, or real-life creative project for students	The main aim is realistic engineering experience, not off the shelf.
	Ongoing Design Issues	ONI, ONI-	Ongoing design situation or issue that may or does still need improvement (often typical if a question has only been partially answered), may have validated the initial question or concern, or for which a specific problem remains to be addressed	Still a concern. Seeing a glimmer of evidence and from that thinking it's working! (A Hurt)
	Problem Solved	SOLVED	The answer to the question led to a definite solution to the problem	Have a network of contacts and eventually found a solution

CODE	CODE NAME	CODE	DEFINITION	EXAMPLES
DESIGNING (continued)	Problem Partially Solved	PSOLVED	The answer to the question led to a definite partial solution to the problem	Some students did access it and shared with me the information that they had clearly gotten from the instructional materials and the online resources. A very set number, but it was clear. Could see it could work - light at the end of the tunnel.
OTHER	Novice/ Expert Issues	N/E	Novice/expert divide: coping with the novice/expert divide, trying to take the perspective of a novice, etc. Also known as the expert effect.	I attempted to look at it from the student perspective to try and guess, since I'm not familiar with the material, where they're going to get hung up, which is generally not the same places I get hung up in.
	Reality (Barriers, Constraints)	REALITY	The reality of the facts, project, activity, etc. Includes workload concerns. Something that just is, and has to be accepted. May reflect surprise or resignation.	Reality woke me up - more complex than expected.

APPENDIX L. INTERCODER RELIABILITY CALCULATIONS

Intercoder Reliability Agreement Calculations - Phase 1, Round 1 (Independent)

% Agreement = [1 - (Mismatches/Category Total)]*100

Category	Total	Coder	Mismatches	Calculations	Percent Agreement
Helps	100	One	72	[1- (72/100)]*100	28%
		Two	66	[1- (66/100)]*100	34%
Hurts	68	One	57	[1- (57/100)]*68	16%
		Two	60	[1- (60/100)]*68	12%
Answer	96	One	72	[1- (72/100)]*96	25%
		Two	60	[1- (72/100)]*96	37%
Source	106	One	34	[1- (72/100)]*106	68%
		Two	46	[1- (72/100)]*106	57%

Determination: Unacceptable level of intercoder reliability.

Intercoder Reliability Agreement Calculations - Phase 1, Round 2 (Negotiated)

% Agreement = [1 - (Mismatches/Category Total)]*100

Category	Total	Coder	Mismatches	Calculations	Percent Agreement
Helps	100	Two	2	[1- (2/100)]*100	98%
Hurts	68	Two	3	[1- (3/100)]*68	96%
Answer	96	Two	2	[1- (2/100)]*96	98%
Source	106	Two	0	[1- (0/100)]*106	100%

Determination: Acceptable level of intercoder reliability (>90%)

Intercoder Reliability Agreement Calculations - Phase 2, Round 1 (Independent)

% Agreement = [1 - (Mismatches/Category Total)]*100

Category	Total	Coder	Mismatches	Calculations	Percent Agreement
Questions	105	Two	48	[1- (48/105)]*100	54%
Basis	105	Two	66	[1- (66/105)]*100	37%

Determination: Unacceptable level of intercoder reliability.

Intercoder Reliability Agreement Calculations - Phase 2, Round 2 (Negotiated)

% Agreement = [1 - (Mismatches/Category Total)]*100

Category	Total	Coder	Mismatches	Calculations	Percent Agreement
Questions	105	Two	6	[1- (/105)]*100	94%
Basis	105	Two	2	[1- (66/105)]*100	98%

Determination: Acceptable level of intercoder reliability (>90%)

Overall percentage of agreement = 94% (using lowest value to be conservative)

APPENDIX M. FINAL CODEBOOK

CODEBOOK 101014 Rev. 5				
CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
HOW	How	HOW	Needing or receiving guidance on how to do something	How will the new material fit in with what I've been doing?
WHAT	What	REF	Guidance, needs, or insight for what to use or do, including how much of something to use (WHAT). References, hardcopy or digital (REF).	Knowing the most common disease cases that would be tested for (WHAT). Book, dissertations, articles. Go on the Internet and find reliable sites.(REF)
WHEN	When	TIME, TIME+	Available time as a factor (TIME). Increase in time available (TIME+).	Not a good use of time (TIME). It would free up my time from preparing a lecture. (TIME+)
WHERE	Where	WHERE	Concern about locating a source for something	Where can I learn this?
WHO	Who (general)	WHO	Expressing a need related to locating or learning about specific individuals	I needed to ask a contact at another university for contacts in other related labs.
WHY	Why	WHY	A question or concern that is focused on why.	Why isn't it working?

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
WHO (continued)	Students	STU	Students, student background, learning styles, level of skill or experience, demographics	We have a very diverse body of students. I was afraid weaker students would bring higher students down. It takes away their own work time.
	Myself	SELF, EDU	Myself, me, my own experience or education (EDU) provided guidance	Knowing relationships are important. Personal philosophy. My own experiences in grad school. Past experience. I was the student who wasn't good at this.
	Peers	PEER	Guidance from, discussion with, or observation of colleagues, specific peers, program or project manager, department chair, etc. Targets design support rather than emotional support/motivation.	Talking to colleague who taught a similar course about what they did. Needed language, so I borrowed prompts from colleagues
	Administra-tive Guidance or Issues	ADMIN	General administrative or institutional guidance, program level or higher. Policies, legal requirements, etc.	Curriculum committee. The program goal of retention in industry three years after graduation.
	Employers/ Industry (general)	EMP	Guidance from external employers/industry	[The basis for the question is] turnaround in industry. Staffing issues are chronic.

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
WHO (continued)	Manufacturers and Vendors (technical, equipment or facility support)	MFV	Guidance from or discussion with external manufacturer or vendor, generally to address equipment-specific issues.	[Helps were} Ideas, textbook, equipment manufacturers.
	Unspecified Sources of Human Help	GOT HELP	External help from other people, groups, or agencies was received. Use this when none of the other help-related codes apply.	Found someone to help.
	Teamwork	TEAM	Working in depth with others to develop a new course, curriculum, etc.	Worked with the other professor to review textbooks, choose text, and suggest lab work.
PROBLEMS/ CONCERNS	Concern for Myself	CSELF	Concern about self	The critique process exposes a vulnerability. Teachers are expected to know all this, but we're constantly learning.

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
	Concern for Students	CSTU	Concern about students, current or future	Didn't want to slam students or ask too much. Yes, that concern could have (hurt) because if the two groups didn't communicate properly the project wouldn't come to fruition and it would cause frustration among the groups. That was a potential problem.
PROBLEMS/ CONCERNS (continued)	Equipment, Facilities and Technology Problems	EQUIP	Problems with or selection of equipment computers, lab equipment, software, etc.	What lab equipment is available to me?
	Instructional Content	CONTENT	Problems with instructional content, including provided textbooks	Wanted a text with good figures in it and good and reliable animations.
	Sequencing of Information or Activities	SEQ	Sequencing concern	Other class provides background for my class, but lecture class was after my lab class!
	Accessing Information	ACCESS	Concern about access to information, including the Internet	How to access things on the Internet, what type of timeframe they [students] would have for that.
	Interdisciplinary or Cross-Disciplinary Issues	INTER	Concern about interdisciplinary issues	How to incorporate interdisciplinary lesson development?

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
PROBLEMS/ CONCERNS (continued)	Evaluation	EVAL	Evaluation concern or evaluation of students	How to evaluate students?
SELF-EFFICACY, MOTIVATION, CURIOSITY and LEARNING	Self-efficacy	SE	Self-efficacy. Belief in one's ability to succeed in specific situations (Albert Bandura). Designer may increase self-efficacy, but still acknowledge anxiety or fear with respect to the design situation. Includes accomplishments such as learning something necessary for designing.	My courage came from knowing this was going to be small enough that with my regular budget I can handle it. Anxiety was reduced after discussion with colleague. If I knew more then I could explain better and have more confidence. I don't have advanced skills.
	Motivation and Curiosity	MOT, CUR	Motivational factor for the participant - happenings or feelings that keep the participant interested in continuing the design process. Curiosity, as an interest in learning and new things, is a motivational factor.	My own experiences. I want to understand everything, nothing appears to be off limits (CUR). Faculty receive email blurbs/articles with interesting questions and information on how to improve a course. I was encouraged to try new things (MOT).
	Doing the Design	DOING	Learned it as I was doing (piloting) the design during the design experience	Tried out machining, etc. And learned. Trying it in class.

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
SELF-EFFICACY, MOTIVATION and LEARNING (continued)	Student Feedback	STUF	Designer/instructor received feedback from students on part or all of the new design or on past design. Includes running a pilot class.	Looked at last years' student reviews. I thought students wouldn't like one thing, but reviews liked it. Surprise!
	Student Learning and Success	SLRN	Evidence that students are learning and succeeding	Students continue to learn and inquire, sense shortcomings and address them or ask for help rather than hiding things.
	Lessons Learned, Best Practices and Advice	LLBA	Lesson learned by the participant, best practice, advice for other designers and instructors	Until you've been through it once you're not very good at answering that question. So with technology I like to see if there is some fun, artistic thing you can do because I latch onto that, that gives me motivation to learn.

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
DESIGNING	Realizing a Need for or Encountering Something New	NEW	Course, associated design activity, design context, instructional content or method, etc. is new to designer.	Build an inventory list of skills and employable outcomes. This is what was different for me, working with these employers. The employers are the content experts for new technologies, the innovators, and have new knowledge that we don't have.
	Worsening Design Situation	WORSE	An answer or action made the design situation worse	It didn't help - made things more difficult.
DESIGNING (continued)	Design is Stopped	STOP	Progress on part or all of the design was halted due to an unexpected problem.	We didn't have a facility. No room, no space, no program!
	Understand-ing Design	UND	Designer obtained a better understanding of the problem or situation (not specific to completing a task or obtaining assistance). Includes thinking through alternatives.	Asking questions improved my understanding. The experience forced me to think through alternatives
	External Representa-tion of Design	EXT REP	Creating an external representation to aid with the design process at the brainstorming level, such as a sketch, diagram, list/outline	I made a SWOT diagram (Strengths, Weaknesses, Opportunities, Threats)

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
DESIGNING (continued)	Direction of Design	DIR	Participant had more direction toward a goal, is on track	Helped to keep me on track going ahead with new design and activities.
	Designing Real Life Project-Based Learning Experiences	DESPROJ, HANDS ON, CREATIVE	Creating a realistic design project, realistic hands-on project, or real-life creative project for students	The main aim is realistic engineering experience, not off the shelf.
DESIGNING (continued)	Ongoing Design Issues	ONI, ONI-	Ongoing design situation or issue that may or does still need improvement (often typical if a question has only been partially answered), may have validated the initial question or concern, or for which a specific problem remains to be addressed	Still a concern. Yes, but partial. I'm hesitant about saying I got a real answer - the two groups didn't work well. I'm sure there could be a way to make them work together. How to address this? There was no real answer at that time, I was just trying to keep an eye on the issue.
	Problem Solved	SOLVED	The answer to the question led to a definite solution to the problem	I have a network of contacts and eventually found a solution
	Problem Partially Solved	PSOLVED	The answer to the question led to a definite partial solution to the problem	Some students did access it and shared with me the information that they had clearly gotten from the instructional materials and the online resources. A very set number, but it was clear. Could see it could work - light at the end of the tunnel.

CODE	CODE NAME	SUBCODES	DEFINITION	EXAMPLES
OTHER	Novice/Expert Issues	N/E	Novice/expert divide: coping with the novice/expert divide, trying to take the perspective of a novice, etc. Also known as the expert effect.	I attempted to look at it from the student perspective to try and guess, since I'm not familiar with the material, where they're going to get hung up, which is generally not the same places I get hung up in.
OTHER (continued)	Reality (Barriers, Constraints)	REALITY	The reality of the facts, project, activity, etc. Includes workload concerns. A statement that means that's just the way things are and it has to be accepted. May be accompanied by resignation (with previous experience) or surprise (if new to the participant).	Reality woke me up - more complex than expected. The class this fall is going to be much smaller than it used to be. The previous class had 30 students. This year I anticipate about 20 students.
	Teaching	TEACH	Teaching newly developed material to students (not a pilot test of the design, and not designing while teaching).	I presented the PowePoint to the students.

APPENDIX N. SENSE-MAKING DATA FREQUENCY COUNTS

Dervin's Five W's and an H, Plus	Coding Category	Totals	% of Total Codes	STEPS 100	QUESTIONS 157	BASIS (Why) 157	HELPS 152	HURTS 139	ANSWER 146	SOURCE 157
How	Evaluation	7	0.6	2	1	2	0	0	1	1
How	How (General)	72	6.0	8	47	2	5	1	9	0
What	Administration	31	2.6	3	3	6	4	0	1	14
What	Equipment, Facilities and Technology	15	1.2	1	3	3	1	6	0	1
What	Instructional Content	33	2.7	5	12	6	3	5	0	2
What	Lessons Learned (Best Practices and Advice)	15	1.2	4	0	4	3	1	2	1
What	Realizing a Need for or Encountering Something New	32	2.7	26	4	2	0	0	0	0
What	Sequencing Information or Activities	5	0.4	0	3	2	0	0	0	0
What	Student Feedback	25	2.1	2	0	3	12	0	3	5
What	What (General)	107	8.9	5	42	15	11	16	17	1
When	Time Concern(Availability)	26	2.2	1	6	6	3	8	1	1
When	Time Increase (Availability)	4	0.3	0	0	0	2	0	2	0
When	When (General)	4	0.3	1	1	0	0	0	0	2
Where	Where (General)	3	0.2	0	2	1	0	0	0	0
Who	Concern for Myself	65	5.4	2	20	10	1	31	1	0
Who	Concern for Students	75	6.2	0	21	16	5	32	1	0
Who	Curiosity	1	0.1	0	0	1	0	0	0	0
Who	Motivation	30	2.5	1	3	6	15	1	1	3
Who	Self-efficacy	72	6.0	3	11	7	12	16	20	3
Who	Students	29	2.4	1	7	17	1	1	0	2
Why	Why	2	0.1	0	2	0	0	0	0	0

Dervin's Five W's and an H, Plus	Coding Category	Totals	% of Total Codes	STEPS	QUESTIONS	BASIS (Why)	HELPS	HURTS	ANSWER	SOURCE
				100	157	157	152	139	146	157
Barriers, Attitudes, Emotions, Constraints	Reality	28	2.3	2	1	14	3	4	0	4
Goal-	Problem Partially Solved	15	1.2	1	0	0	5	0	9	0
Goal+	Problem Solved	26	2.2	2	0	0	4	0	20	0
Resources	My education	17	1.4	0	0	4	2	0	1	10
Resources	References	42	3.5	7	1	3	20	0	0	11
Who as a Resource	Employers and Industry	33	2.7	6	3	6	6	0	0	12
Who as a Resource	Help (General)	4	0.3	1	0	0	1	0	2	0
Who as a Resource	Manufacturers and Vendors	3	0.2	0	0	1	2	0	0	0
Who as a Resource	Myself	153	12.7	0	0	39	8	2	1	103
Who as a Resource	Peers	38	3.2	4	1	3	18	0	0	12
Who as a Resource	Teamwork	4	0.3	3	1	0	0	0	0	0
Who as a Resource	Who (General)	16	1.3	5	5	3	3	0	0	0
Situation	Improved Direction for Design	9	0.7	0	0	0	3	0	6	0
Situation	Improved Understanding of Design Situation	37	3.1	6	1	3	11	5	11	0
Situation	Ongoing Design Issues	59	4.9	1	1	1	3	0	53	0
Situation	Problematic Ongoing Design Issues	12	1.0	0	0	0	0	5	6	1
Situation	Worsening Design Situation	5	0.4	1	0	1	0	1	2	0

Dervin's Five W's and an H, Plus	Coding Category	Totals	% of Total Codes	STEPS	QUESTIONS	BASIS (Why)	HELPS	HURTS	ANSWER	SOURCE
				100	157	157	152	139	146	157
Stop	Design Progress is Stopped	8	0.7	1	2	2	0	3	0	0
Verbing	Creating External Representations of Design	2	0.2	2	0	0	0	0	0	0
Verbing	Doing/Piloting the Design	15	1.2	4	0	0	6	0	2	3
Verbing	Teaching	1	0.1	1	0	0	0	0	0	0
How, What	Creating a Creative (for students) Learning Experience	1	0.1	1	0	0	0	0	0	0
How, What	Creating a Design Project Learning Experience	2	0.2	1	0	1	0	0	0	0
How, What	Creating a Hands-on Learning Experience	2	0.2	2	0	0	0	0	0	0
How, What, Who	Interdisciplinary or Cross-Disciplinary Issues	4	0.3	2	2	0	0	0	0	0
How, What, When, Where	Accessing Information or Technology	1	0.1	0	0	1	0	0	0	0
How, What, Who, Why	Novice/Expert Issues	7	0.6	1	1	2	2	1	0	0
What, Who	Student Learning and Success	7	0.6	1	0	0	3	0	3	0

APPENDIX O. AD-HOC DESIGN MAPPING ANALYSIS

This section discusses the development of an ad-hoc design mapping analysis to explore commonalities between the questions asked by faculty during design of instruction and questions asked by designers in other design domains. Included are a definition and description of design mapping, the basis for design mapping, expectations for design mapping, a description of the design mapping team, and information on pilot testing and implementation.

O.1 What is Design Mapping?

Design mapping is a strategy for revealing a complex of relationships between design representation and thinking, technology, culture, and aesthetic practices, often focused on visualization of data and ideas (Newman, 2013). The term 'design mapping' is frequently used as a synonym for mind mapping, concept mapping, or as a visualization tool used in conjunction with design thinking, but also applies to process mapping, including design process mapping for both new and existing systems and products. Within the context of this study, design mapping is used to explore similarities in questions and cognitive question-asking behavior between the study data on conceptual design performed by higher education faculty and designing in other design domains, including commercial nuclear power.

O.2 Basis for Design Mapping

RO3 ties to the overarching goal of this study: to provide a basis for future research to investigate whether techniques used to help people with question-asking during design in commercial nuclear power can be useful to help designers with question-asking during design in domains outside of nuclear power.

During development of this research study, three important issues arose in connection with the overarching goal of this study:

1. A common response from academic peers to the researchers' enthusiasm about research on techniques from nuclear power was 'I don't care what you learned in nuclear power because nuclear power is nothing like what I do.' As a potential barrier to future research, this is an issue that needs to be addressed.

2. Previous pilot testing of an intervention to test a technique from nuclear power to help designers learn to ask better questions during design had encouraging results, but it is not realistic to perform research on those interventions as part of this dissertation research. The dissertation research focuses on question asking behavior of faculty during initial conceptual instructional design.

3. At the ICAD 2013 conference design researchers, design educators, and practicing designers from industry expressed to the researcher the need for better ways to learn to ask good questions during design and to teach their students better ways to ask questions during design.

These three issues led to a dilemma: how to address the overarching goal of this study to provide a basis for future research investigating whether techniques used to help people with question-asking during design in commercial nuclear power can be useful to help designers with question-asking during design in domains outside of nuclear power. A need for future research has been verified within a small community of designers, and a possible approach for future research has shown promise, but to provide a stronger basis and potential funding for future research across a wider range of design domains it is very important to be able to address issue #1. An obvious solution might seem to be obtaining design documentation from commercial nuclear power to demonstrate similarities with design in other arenas, but for security reasons that is not possible.

What is possible, and relatively straightforward as it is based directly on data collected in this study, is to compare the questions asked by participants in this study with questions asked by designers in other design domains, including nuclear power. Design mapping was selected as the means to compare questions across design domains and address RO3 with respect to the overarching goals of this study because it is a good fit as a data analysis strategy for revealing complex design relationships. Design mapping is also a good fit with Dervin's concept of circling reality, simply extending the circling from study participants to the broader sphere of design in multiple additional design domains.

O.3 Expectations for Design Mapping

Design mapping may be able to provide a conceptual basis to refute the argument from academic peers and others that '….nuclear power is nothing like what I do' by illustrating the concept of design as a discipline with respect to questions. This is anticipated to be a two-part effort:

A. If a design mapping team of design experts from domains other than instructional design in higher education can show parallels/commonalities between question asking behavior in higher education (the dissertation research data) and question asking behavior in their own design domain(s), then that supports the concept of design as a discipline with respect to questions asked.

B. If design mapping shows commonalities between questions asked during design in nuclear power and questions asked during design in other disciplines, that would provide support for future research investigating techniques from nuclear power to help people ask questions during design in other design arenas. .

O.4 Design Mapping Team

The design mapping team consists of eight design experts:

1. A Mechanical Engineering professor and Axiomatic Design expert.
2. A Graphic Design / Fine Arts professor.
3. A Senior Power Supply Coordinator for an electric company with extensive nuclear power industry experience.
4. A Senior Manager of Corporate Design Engineering in the nuclear power industry.
5. A Culinary Arts professor.
6. An Electrical Engineer and PreK-5 design education and critical thinking expert.
7. A Clinical Supervisor from a university medical center Department of Psychiatry with design background in instructional design and nuclear power.
8. The researcher.

O.5 Design Mapping Pilot Test

An emergent expertise-oriented formative evaluation was performed by selected members of the design mapping team to map question data to design as a discipline, using a combination of perceived value from participants, and expert judgment from industry design experts who have lived design as a discipline. Data was reviewed by the researcher and two other design-as-a-discipline experts to attempt mapping of question data to the larger arena of design as a discipline. Design experts were asked to provide feedback on how the provided questions and related issues apply to what they have experienced during design (or not).

Initial design mapping data consisting of questions/concerns and associated context was provided to the two designated design mapping team members for a design mapping pilot test. The pilot testing team received an Excel spreadsheet containing study participants data on steps, questions, and question context. The spreadsheet contained design mapping fields for design mappers to provide their design disciple(s), whether the participants question applied in their design domain, an example of a similar question from their design domain (if the participants question applied), and space for comments. Field headings were modified slightly to be more user-friendly as Sense-Making specific vocabulary was not required. See Figure 24 for an example of the data and mapping format provided for pilot testing. Instructions, examples of design mapping and a copy of the interview protocol were also provided.

IDENTIFIERS			DESCRIPTIONS		CONTEXT		
ID	Step	Q#	Step Descriptions for Initial Conceptual Design	Question or Concern Description	Basis for Question	What Helped Me?	What Hurt Me?
TEST	1	1.3	My first experience with case studies took place at a conference	How to fit this into the timetable of the class?	My understanding of how tight my schedule was, and the need to meet mandated goals for the course. Timing is big.	References. Readings were very helpful and I went to a mini case study approach.	My lack of understanding could have hurt me if I didn't give students enough time for exercises.I had to apply what I learned and be flexible.

CONTEXT		DESIGN MAPPING			
How an Answer Helped	Source of Question	My Design Domain	Question Apply in My Design Domain?	Similar Question in My Design Domain?	Comments
I understood how to fit it in and make it succeed in a limited time frame.	My own experience				

Figure 24. Example of Design Mapping Pilot Test Data

The pilot testing team mapped participants' questions to their own design domains.

After test data was compiled, the pilot testing team held a brief teleconference to discuss the results. Changes resulting from the test run included:

1. Streamlining and clarifying the instructions and adding a purpose statement.
2. Highlighting the Questions column and put it before the Steps column so the primary field for analysis comes first and stands out.
3. Including the interview questionnaire to provide additional context.
4. Setting up the design mapping spreadsheet for the actual design mapping.

O.6 Implementation

Design mapping spreadsheets were distributed to the team. As no one appears to have taken this approach to question analysis before, we really weren't sure what to expect. Based on the pilot test and initial feedback from several design mapping team members, three approaches to design mapping are in use. The first is explained in detail to illustrate the thought process involved:

APPROACH A: TREES TO CAKE

Objective: Look at participants' questions/concerns and think of a similar question/concern in your design domain.

<u>Getting from Trees to Cake:</u>

Thought process for getting from trees to cake:

1. Look at question or concern: "What trees should I plant?"

2. Look at context: from the basis for the question, multiple types of trees are being considered, and design choices need to satisfy the customer.

3. Think about what's involved in determining which trees to use in landscape design. If you were going to plant a bunch of trees at your house, you'd probably start by considering things like tree size, shape, type (example: pine, maple, apple), color of fall foliage, etc.

4. Thinking about tree selection a little more, there are specific varieties (golden delicious apples or Macintosh?), shapes, foliage colors, sizes, etc. involved, as well as more specific details like leaf shape or color of flowers or bark that you'd decide on as the design progresses.

5. Think about wedding cake design and how it could be similar to selection of trees for landscaping design. When you choose a wedding cake, you look at shape of the cake (tiered, for example), flavor, frosting color, type of decorations and colors, size, etc. Basically, a style of cake is selected and then details are worked out as design progresses.

6. By now, it can hopefully be seen that there are similarities between selection of trees and selection of cakes during the design process. Both involve selection of types, colors, size, etc. That leaves the issue of satisfying the customer. Cake designers also have customers/clients.

7. Look at the original question or concern again: "What trees should I plant?"

Think about how that question may be able to be translated from landscape design to cake design.

Since we've established parallels between trees and cake and customers and clients, we can equate "What trees should I plant?" to something like "What cake should I make?"

But I didn't want to use quite such a literal translation, so I used something a bit more specific that tied in cake style and implied a tie to clients. I used "What style of cake is wanted?" along with specifying dependence on client needs in the comments.

APPROACH B: REVERSE ENGINEERING OF QUESTIONS

Objective: Look at participants' questions/concerns and overall design situation. Think of a similar design situation you have been in where you had a similar problem/concern. Describe the problem and solution (if any) and then restate the discussion in terms of design-related questions that you had.

APPROACH C: RELATING QUESTIONS TO PAST DESIGN PROBLEMS

Objective: Look for similarity between the participants' question and similar design situations you have experienced, such as problems involving technical factors, process factors, data voids, subject matter expert seeking, motivation of self and others and all of the risks and rewards inherent in classroom teaching. Most questions are fundamental to the overall process of designing a solution and differ primarily in the details of the answer rather than the form of the question.

O.7 Design Domain Data and Domain Definitions

Design mapping data was received from three design mapping team members, and included design domains from commercial nuclear power and multiple non-nuclear power disciplines (refer to Table 25 for an example of mapped data). This range of domains is important, as including both nuclear and non-nuclear domains provides potential to discover indications of design as a discipline across a larger design arena, providing stronger proof of concept for future research.

The number of design domains incorporated by the three mappers was much larger than anticipated: a total of 47 design domains, some of which may not be familiar to all readers. As a result, design mappers were asked to provide definitions of their design domains, as they are the experts on their own design domains. Design domain definitions are provided in Table 26 and include the following information:

ID: Identification number for the Design Mapping Team Member

Design Domain: The design domain(s) of the Design Mapping Team Member

Design Domain Definition: A description of the design domain as provided by the design mapping team member.

O.8 Example of Design Mapping

Examples of design mapping data are shown in section 4.9.

Note that sometimes the design mappers provided information on how they addressed a specific design issue. Explanation of the design domains is provided in Table 26.

Table 26. Design Mapping Team Design Domain Definitions

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
1	Nuclear Design Engineering	Nuclear Design Engineering is responsible for ensuring nuclear power plant configuration is established and maintained throughout the design, construction, turnover, and operation phases of plant life. Design Engineering is responsible for the following: 1. Ownership of the processes and procedures for design, design control, and design documentation 2. Establishing design basis for safety structures, systems, and components (SSCs) 3. Establishing documentation of design basis for SSCs 4. Developing design requirements for SSCs 5. Documenting design requirements for SSCs a. Specifications b. Calculations and analyses c. Drawings d. Databases 6. Evaluating and resolving differences (including documentation update) between as-designed and as-built configuration during procurement, construction and startup 7. Evaluating and resolving non-conforming conditions 8. Evaluating, preparing, and controlling changes to design requirements during design, fabrication, construction, startup and operation phases 9. Providing basis and review of operational documents (procedures, tests, and maintenance instructions) 10. Regulatory interface, including preparation assistance and technical review of license documents 11. After turnover of modifications to plant operations, Design Engineering should clearly identify the “documents of record” which will be updated to reflect the as built configuration.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
2	Nuclear Power Plant Operation	Refers to the operating shift crew of one or more Auxiliary Operators for the primary and secondary side equipment, Licensed Reactor Operators to manipulate the control room controls, and Licensed Senior Reactor Operators who supervise operations.
2	Nuclear Power Plant Configuration Management	Can be different at different plants, but in this case refers to evaluating and participating in planned engineering design changes to the power plant, identifying all of the work groups impacted by the change and ensuring they are appropriately trained, their work processes adjusted, and finally ensuring the power plant simulator performance and hardware is modified to remain faithful to plant look, feel and performance.
2	Simulator Training for Nuclear Power Plant Operators	Refers to training of licensed operators in normal and off normal procedures and processes in a replica of the plants main control room.
2	Nuclear Power Plant Systems Training for Electrical, Mechanical and Civil Engineers	An intermediate level course to teach new and near new engineers in the major systems that make up the power block. For example Feedwater, Main Steam, Rod Control, Main Generator etc.
2	Nuclear Power Plant Licensed Reactor Operator Training	Training of individuals in the specifics of manipulating the controls of a nuclear power plant, as well as training on emergency procedures and accident response. Training is generally one to two years in length culminating in a Nuclear Regulatory Commission administered written and oral exam. Both oral and written exams can be 4 to 8 hours in length.
2	Designing a Software Tool for Wholesale Electric Power Scheduling and Financial Settlement	At the wholesale power level, each generator must submit a daily bid for how much power they will produce the next day, how long they will run, and at what price they are selling their power. Each load-serving entity must submit a forecast of their expected load the next day by hour. The regional transmission operator (RTO) will then select generation on a least cost basis to run during the operating day. The day after the operating day, actual metered load and metered generation is reported. Financial settlement is performed, paying to the generators the hourly price at their generator bus and collecting from load the hourly price at the load bus.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
2	Wholesale Electric Production and Distribution Workforce Development	A typical workforce will forecast load and generation, budget for power costs, purchase or sell power on a long term basis, write contracts, monitor credit ratings of those companies it does business with, borrow money to operate, manage its transmission and distribution system, generate rates for billing wholesale customers, dispatch its own generation, perform financial hedging, run a demand response system, interface with legislators to influence legislation, generate reports and myriad other activities associated with electric power production and distribution.
2	Preparation for Nuclear Regulatory Commission Licensed Reactor Operator Exam	This training took place over a long period of time and involved classroom instruction, walkdown of electrical and mechanical systems, observation training at other power plants, reactor operator training at university test reactors, serving as outside the control room operators under supervision of qualified operators and re-occurring oral and written exams.
2	Radiation Protection Training for Nuclear Power Plant Operators	Operators must be knowledgeable of different types of radiation, their likely sources in a power plant and the biological damage that exposure can cause. They must be familiar with the use of portable monitoring equipment, types of shielding, stay times and the inverse square law. They must know how and when to use anti-contamination clothing.
2	Generic Training (Nuclear power and electric distribution)	This training includes: Nuclear Power Plant general employee training, electric distribution Cooperatives retail access training, wholesale power company financial transmission rights and transmission congestion training. All of these training sessions have common elements of who, where, what, and when. None of these programs require any specialized knowledge to begin.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
2	Transmission Congestion Hedging in Wholesale Electric Power Markets	With the advent of locational marginal pricing in wholesale electric power markets, it is possible to assign a price to every generator and load bus in the transmission system. If the transmission system is unconstrained, the locational price will be the same at all locations. If a segment of the transmission system goes out of service, or reaches its capacity limits, prices in locations associated with that transmission will rise resulting in a congestion price between it and the uncongested part of the system. A financial instrument called a Financial Transmission Right can be purchased that will entitle the holder to the dollar value of the congestion between two points. An entity that has a generator at one location and load at another may purchase a Financial Transmission Right to protect themselves against excessive congestion prices between its generation and load.
2	Essays as a Learning Tool: Nuclear Regulatory Commission (NRC) written and oral exams for operator license	Actually a 'subdomain' of preparation for the NRC exams. NRC test questions are always essays which are structured to get as broad and detailed response as possible. For training purposes, license candidates were also frequently tested using questions that would elicit a detailed and lengthy written response. This encouraged students to organize their thoughts and to be concise yet thorough in their response.
2	Nuclear Consulting Services	A services salesman. Visit different nuclear plants and talk with people in operations, maintenance and training. We would sell them services to write training programs, find qualified personnel to contract as shift technical advisors and supply engineering expertise for mechanical snubber stress analysis. Whatever the clients' services need, we would try to find a way to fill it.
2	Engineering Co-op for Nuclear Power Plant Configuration Management	One of the electric utilities I worked for would hire a number of 3rd and 4th year engineering co-ops each year to give them real work experience in jobs that used similar engineering skills to those matching their education.
3	Adult Learning	Thinking of adult learning overall here, giving consideration to the known factors that affect andragogy. Design question: What are the factors that can tell us how much discovery learning is effective among adults, versus criterion-based design of instruction? Why are those factors most important?

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Church Organ Sales	*How is this a different design domain than car sales?* --Different population with very different needs. Design questions and shaping of strategy involves considerations of group dynamics and political elements for church organ sales. Car sales is most often an individualized or pairs decision by contrast. The ultimate goal of selling may be different also, depending on the stage in the selling process.
3	Clinical Supervision	A process of defining needs, designing interventions and evaluating performance for clinical staff. Design example: tools for measuring competence and needs for development.
3	Coaching	An individualized process of asking questions and responding to patterns of conversation in a way that supports another person's growth and development. Design example: determination when and how from problem assessment to solution-finding. May require iteration to adapt to changing input.
3	Consulting	Process depends on who you ask, but my framework involves fact finding, options definition, definition of milestone outcomes and development of trust with stakeholders. Each of those will demand a custom strategy for different clients with different needs.
3	Counseling	A process of developing a therapeutic alliance, listening to understand subjective experience of the client, empathy and choice of strategy including individualized goals. Design decisions would include development of an individualized treatment plan based on client's strengths, responses to treatment, mental capacity, relationships and resources.
3	Family Therapy	A separately-defined therapeutic process and role for the therapist including choices of who in the family to meet with, how to pursue themes and issues occurring between people in the family system. Design would include timing of interventions with different family members, assignments to be completed outside of the therapy session and decisions about how to find and apply family strengths to problem solving.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Group Counseling	Facilitation of a process of interaction among non-related individuals with some experience or need in common. Goal is for group members to gain support (Universalization) and learn from others through sharing narrative descriptions of relevant life experience. Also an existential element as the group develops relationships with each that reflect their roles and experience outside of therapy. Design introduces new group members and strategies for facilitation of unique groups.
3	Group Supervision	Similar to instructional design, includes the facilitation of learning from problem solving as a group. Strong discovery learning component. Group members may be from different levels and types of experience. Design example: Decisions about how to get necessary input from members without taking too much time, and how to facilitate flexibility and willingness to learn among group members.
3	Improvisation - Music	Improvisation, different from composition, involves aural abilities of interpretation and the 'live' response to music that is occurring in the moment. The music can be interpreted as having meaning, shape or direction and creative response occurs in improvisation that adds to and builds on the existing sounds. This often affects how others are making music at that time through their choices of pitch, rhythm, melody, texture or other factor. Example of design: The structure of the music can vary widely, from strict adherence to written symbol (musical score or part) to complete freedom where nothing is written, only improvised. The design rests in how much freedom versus control is planned and is considered appropriate.
3	Instructional Design	Refer to Appendix A for a definition of instructional design.

3	Instructional Design – Nuclear Power	*Is instructional design different in nuclear power?* In the nuclear power training environment, instructional design is tied more concretely to job and task analyses than in many other settings. This is likely true because of the need for predictability of outcomes and learning that can be managed taking this approach. The training provides less theory, conceptual objectives and discovery learning than is often found in educational settings. The emphasis is placed on the ability of the learner to perform specific job tasks, some as fundamental as repairing a broken machine or performing routine machine maintenance; or as sophisticated as improving decision-making under crisis conditions with multiple, sometimes contradictory factors present, as is found with the tasks of the nuclear plant operator. The design of instruction then, emphasizes detailed objectives that specify the conditions for performance in addition to the standards to which performance can be measured. The idea is for the instruction to provide predictability in performance. This approach is found in other industries where performance and predictability and managed risk is imperative. The 'customer' for the training is often found in regulating bodies who seek to control the quality of instruction and predictability of outcomes. Outside of the nuclear power training environment, training and education's use of instructional design can be more creative and exploratory, more available to discovery learning and self-managed learning. In many educational classrooms, having fun and developing from the energy available from joyful experience, sets the instruction apart from designs working mainly with the repetition of content material, some of which may not be tied to any skill other than passing a test. Classroom instruction also depends more heavily on the facilitative skills of the instructor. In high risk industries such as nuclear power, the emphasis is on the development of efficiency and automaticity, regardless of the delivery mechanism. *(…continued)*

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Instructional Design – Nuclear Power (continued)	Primary design questions - nuclear power: How critical is the task to safety and overall job performance? What effect should criticality have on the design? How frequently are the tasks performed? How can design accommodate the need for frequency of repetition? How difficult is the task? To what degree does the training reflect the operating procedures for the identified task? How will the procedure be used as part of the instruction? What do the regulatory bodies require to be in the training (content)? What standards are given for the design of training by regulating agencies? How is compliance ensured? Design questions - lower risk educational settings: Who is the customer of educational services? How much can the audience be standardized? What are the overarching goals of the education? How much will it cost to provide the education? How much self-direction can be allowed in the education? Aside from passing the test, what are the requirements for completing the course? What role should learner enjoyment play in the design of the classes? How will the quality of the education be judged? To what extent will learners have the opportunity to apply new knowledge inside or outside the classroom? To what extent should interaction between students be encouraged? Plus many more….
3	Leadership Development	Leadership development as a process usually begins with a goal in mind, the model for leadership, and some people who are to be target of the development. The design rests in choosing those people and in defining, implementing and measuring results of strategies aimed at their development. Design example, a mentoring program with defined outcomes, roles, timetables, starting and ending points, and a definition of who is learning versus an open ended experiential development concept that permits learning on the part of all involved including the organization, which may be using the effort to discover and define what leadership is in that organization.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Music Composition	Composition, different from improvisation, most often involves the construction and documentation of a musical form in such a way that it can be duplicated with fidelity to the original structure. Improvisation may occur but is a variable in composition where there may be no expectation of creative expression separate from what is documented. A design example may be best made by highlighting the differences in approach to composition. Some composers may work alone with a piano on hand, trying out different harmonic and melodic components, then documenting them according to their desire for expression. Another composition may propose a particular scale or harmonic combination to a player and allow individual freedom of interpretation to be the composition. Some composers work with a theme and construct elaborations on the theme(s), documenting in detail what they are 'hearing' so that others will produce and reproduce it at a later time.
3	Organizational Consulting	See consulting.
3	Organizational Development	Organizational Development (OD) is a range of practices performed internally by a specialist or externally by a consultant. The overarching goals are to enable organizational change and growth. This can include activities addressing process, organizational structure and technology as well as those addressing the social-interpersonal aspects of the organization. OD uses research from organizational psychology, psych of learning, clinical and counseling psychology to address development needs of groups in the organization. Design example: A work group lacks communication needed to most efficiently get a job done. What are the factors impeding communication? What are the strengths the work group has that can help resolve this problem? What is the best process for ameliorating the problem? Who will facilitate this work? How do roles and job design affect the problem or its potential solutions?

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Organizational Psychology	Organizational psychology adopts a scientific approach to understanding and predicting organizational behavior. It gives names and descriptions to typical effects that work life and the organizational experience has on individuals. Organizational psychology is often called upon to define management policy. Design example: An employee survey. What factors should considered most important when interpreting the results of an employee survey; the response rate, the nature of the questions, the timing of the survey, the comments and, the cost of responding to employee needs, the validity of the survey's results, the history of surveys in the organization, the cost of not responding to employee's needs, how to roll out a response, how to communicate what is understood from the survey and many others.
3	Perfectionism (ie. 'therapy', since that is what is usually designed)	Should be called therapy probably, since perfectionism is often a problem that a therapeutic approach will address. It is considered a diagnostic symptom that demands adjustment in communication style, phrasing, references and metaphors, the current relationship with the person and the person's cognitive process that reinforces their perfectionism. Design considerations: Should the therapist address the cognitive distortions present in the patient or the emotional reactions the patient feels when thinking perfectionistically? How does this vary from person to person? What effect will the setting have on the person's response? What are expectations the person has of the therapist? Is the perfectionistic thinking considered the main problem or is it something else, yet unknown?
3	Performance Management	Performance management is both a designed function with the organization that demands its own approach, and the results of this management activity.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Piano Tuning	*Design aspects versus a technical task?* Tuning is considered an art by some, though on the surface appearing to be a series of mechanical adjustments. The tuner establishes a set point using a tuning fork. From there, a temperament is created, setting intervals (frequencies compared aurally) in relation to the set point. Each piano is different and is supposed to be made in tune with itself, considering the parameters and constraints of the instrument and preference of the customer. Using an electronic tuner for example often provides a tuning that doesn't sound as good as one done aurally. Also, the age of the instrument, its quality of design, history of use and other factors are to be considered when tuning. Design example: Does the instrument hold its tuning well and tend to slip when played heavily? Does the instrument produce the texture (timbre) of sound needed for the best overall sound? Does the customer know the difference or have particular tastes for what they hear coming out of the instrument?
3	Piano Tuning - Instructional Design	Designing instruction for novice piano tuners.
3	Play in Adult Group Learning	Definitions of play embrace a range of experiences and behavior. Play can vary a lot in its structure. It is defined differently from fun in that play can be designed. Fun is the subjective experience of the individual, not always connected to whether they are playing. Play is considered voluntary, the process of it is considered more important than the outcomes, and some play is highly structured such as in games. Play usually allows for imaginative expression and new directions. It is defined in part by its departure from seriousness and play demands high levels of engagement, but not distress. Design example in adult learning: A facilitator intends to stimulate positive feelings as a means of developing group cohesiveness. (S)he considers each of the elements above in deciding how to promote these experiences, choosing which to emphasize according to what is known about the group, her skills as a facilitator, the setting and context defining the need, the history of these kinds of experiences, etc.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Playing Music	*I can see improvisation as design - but how is playing music a design domain in a different way than improvisation or composing or part of song writing?* Differences in design concepts of playing music are defined mainly by whether the player is 'allowed' or expected to improvise. ‘Jamming' usually means adopting musical themes and sharing those with an expectation of improvisation. Classical music usually involves less freedom, where the player's role is only to manifest the expression documented by the composer. A design question might be: How much freedom am I allowed with this piece of music in this setting, with this audience, and these other players?
3	Psychoeducation	Psychoeducation is a process of delivering both information and experience to learners, often those receiving mental healthcare, with a general goals of their gaining insight, expressing their own experience and making decisions about self-care that are beneficial. A design example would be a therapist working with an 'open' group, where group membership changes regularly, deciding what terminology to use as information and what questions to ask to promote self-expression and gained insight, given the existing character, intelligence, cultural background and interests in learner present in a session.
3	Psychosocial Assessment	This and psychosocial evaluation are considered to be the same for this purpose
3	Psychosocial Evaluation	Psychosocial evaluations are used most often in mental health settings as a means of determining the needs of a patient for care. The psych portion looks at the current state of the individual and his ability to function. The social aspect considers the background of the patient, family history of illness, family of origin factors, current social connections and support, education, work or school activity among others. Design example: An addictions clinic is seeking to design a shorter process of determining the initial needs of patients for purposes of admission, and to delay gathering information about the more 'social' factors until after admission. The design needs to consider which questions should be clustered together, which are most critical, who will be each of the steps in the evaluation, how will this affect scheduling for the 1st part and the 2nd part of the evaluation, what does the electronic template need to have in it for user friendliness, the interviewing skills of clinicians, as well as other considerations.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Selling Cars	See defined difference in selling cars from selling church organs above.
3	Social Psychology	Social psychology is the study of individual and group thinking, emotions and perceptions that assumes we define ourselves in relation to others and act according to those definitions. Design example: A researcher wants to know the relationship of age, race and education to social satisfaction from the college experience. An experiment is designed to test several assumptions and make room for new perspectives.
3	Song Writing	Song writing is a subset of musical composition with the addition often of lyrics that complement the song's melodies. Song forms have traditionally followed a certain design in music history and the song has a specific meaning in terms of the composition's structure, length, and sometime themes. Design example: A song writer has a certain theme, subject, episode of people interaction, or relationship between people taken from a play. The designer/writer takes into consideration the likely audience, the theme, the characters, the plot, the timing and other factors that will have an effect on the design process and the end result.
3	Strategic Planning	Strategic planning is defined broadly as a systematic process of envisioning a desired future and setting goals and objectives toward reaching the future state. A design example: A non-profit agency with very few resources assigns roles and creates a meeting structure to get a leadership group to begin strategic planning.
3	Supervision	Supervision has many meanings. The focus for this purpose is the process of translating policy, rules and regulations into strategies for formal and informal interaction between persons in a supervisory role and those they supervise. Design example: A supervisor decides upon a framework for one on one supervision sessions and an approach to a reminder system for completing documentation and plans for care in a clinical setting. Recommendations for the practice of clinical supervision.
3	Team Building	Same as team building for this purpose.

ID	DESIGN DOMAIN	DESIGN DOMAIN DEFINITION
3	Team Development	Team development has many manifestations. The general idea is for a group of people to develop interpersonal trust, to increase group cohesiveness and general effectiveness in working together. Teams are mainly task oriented, making them different in some ways from other groups. Design example: An organization is undergoing major structure change adapting to a new integrated software system to be launched enterprise-wide. A team needs to be formed to reflect the cross-disciplinary integration of functions. A design for who should be on the team, how often they should meet etc., will need to give consideration to the history of cross-functionality, the skills and abilities of potential team members, the charter for the teams focus, leadership within the team and other considerations.

O.9 Design Mapping Results

Design mapping data was analyzed by determining the percentage of study participant's questions that were successfully mapped to questions in the design mappers design domains. The results are displayed in Table 27 which includes the following information:

Team Member: Identification number for the Design Mapping Team Member

Design Domain: The design domain(s) of the Design Mapping Team Member

Questions Analyzed: The number of questions collected from higher education faculty for conceptual instructional design that the Design Mapping Team member attempted to analyze for a specific design domain.

Questions Mapped: The number of questions collected from higher education faculty for conceptual instructional design that the Design Mapping Team member successfully mapped to his or her own questions in a specific design domain.

Questions Not Mapped: The number of questions collected from higher education faculty for conceptual instructional design that the Design Mapping Team member did not map to his or her own questions in a specific design domain.

Comments: An explanation for unmapped questions, if available.

Refer to sections 4.9 and 5.8 for more information on the results and implications of design mapping.

Table 27. Design Mapping Frequency Counts

Team Member	Design Domain	Questions Analyzed	Questions Mapped	Questions Not Mapped	Comments
1	Nuclear Design Engineering	122	106	16	Six (6) question topics were determined not to be applicable (example: TurnItIn.com). After beginning review of questions from an instructional design novice, ten (10) more questions were not attempted because they were seen as not adding value.
1	Totals	122	106	16	Total Mapped Successfully: 87%
2	Nuclear Power Plant Operation	11	11	0	Mapped Successfully: 100%
	Nuclear Power Plant Configuration Management	6	6	0	Mapped Successfully: 100%
	Simulator Training for Nuclear Power Plant Operators	5	5	0	Mapped Successfully: 100%
	Nuclear Power Plant Systems Training for Electrical, Mechanical and Civil Engineers	10	10	0	Mapped Successfully: 100%

Team Member	Design Domain	Questions Analyzed	Questions Mapped	Questions Not Mapped	Comments
2 cont.	Nuclear Power Plant Licensed Reactor Operator Training	5	5	0	Mapped Successfully: 100%
	Designing a Software Tool for Wholesale Electric Power Scheduling and Financial Settlement	5	5	0	Mapped Successfully: 100%
	Wholesale Electric Production and Distribution Workforce Development	8	8	0	Mapped Successfully: 100%
	Preparation for Nuclear Regulatory Commission Licensed Reactor Operator Exam	9	8	1	Question on "How to support students yet be appropriately critical while providing feedback for improvement" is not applicable. Student driven, feedback is immediate. Student is motivated to gain license, so seeks knowledge to improve likelihood of success. Mapped Successfully: 89%
	Radiation Protection Training for Nuclear Plant Operators	5	5	0	Mapped Successfully: 100%

Team Member	Design Domain	Questions Analyzed	Questions Mapped	Questions Not Mapped	Comments
2 cont.	Generic Training (Nuclear Power Plant general employee training, electric distribution Cooperatives retail access training, wholesale power company financial transmission rights and transmission congestion training)	7	7	0	Mapped Successfully: 100%
	Transmission congestion hedging in wholesale electric power markets	8	8	0	Mapped Successfully: 100%
	Essays as a learning tool (Nuclear Regulatory Commission written and oral exams for operator license)	7	6	1	Turnitin.com is not applicable. Mapped Successfully: 86%
	Nuclear Consulting services	8	8	0	Mapped Successfully: 100%

Team Member	Design Domain	Questions Analyzed	Questions Mapped	Questions Not Mapped	Comments
2 cont.	Engineering Co-op for nuclear power plant Configuration Management	12	9	3	Concern about co-op program that employers may not be interested or don't want to take the time does not apply [for this workplace]. The company has a regular program of hiring engineering Co-ops for the summer. Concern that maybe only one company is using older technology: Many companies still use older technology that is effective and therefore have no incentive to upgrade. Mapped Successfully: 75%
2	Totals	106	101	5	Total Mapped Successfully: 95%
3	Adult Learning	1	1	0	Mapped Successfully: 100%
3	Church Organ Sales	1	1	0	Mapped Successfully: 100%
3	Clinical Supervision	15	15	0	Mapped Successfully: 100%
3	Coaching	1	1	0	Mapped Successfully: 100%
3	Coaching (and counseling)	1	1	0	Mapped Successfully: 100%
3	Consulting	4	4	0	Mapped Successfully: 100%
3	Counseling	11	11	0	Mapped Successfully: 100%

Team Member	Design Domain	Questions Analyzed	Questions Mapped	Questions Not Mapped	Comments
3	Family Therapy	1	1	0	Mapped Successfully: 100%
3	Group Counseling	1	1	0	Mapped Successfully: 100%
3	Group Supervision	1	1	0	Mapped Successfully: 100%
3	Improvisation-Music	1	1	0	Mapped Successfully: 100%
5	Instructional Design	1	1	0	Mapped Successfully: 100%
3	Instructional Design - Nuclear	1	1	0	Mapped Successfully: 100%
3	Leadership Development	1	1	0	Mapped Successfully: 100%
3	Music Composition	2	2	0	Mapped Successfully: 100%
3	Organizational Consulting	1	1	0	Mapped Successfully: 100%
3	Organizational Development	14	14	0	Mapped Successfully: 100%
3	Organizational Psychology	3	3	0	Mapped Successfully: 100%
3	Perfectionism (should be 'therapy', since that is what is usually designed)	1	1	0	Mapped Successfully: 100%
3	Performance Management	3	3	0	Mapped Successfully: 100%
3	Piano Tuning	16	16	0	Mapped Successfully: 100%
3	Piano Tuning - Instructional Design	1	1	0	Mapped Successfully: 100%

Team Member	Design Domain	Questions Analyzed	Questions Mapped	Questions Not Mapped	Comments
3	Play in Adult Group Learning	1	1	0	Mapped Successfully: 100%
3	Playing Music	1	1	0	Mapped Successfully: 100%
3	Psychoeducation	1	1	0	Mapped Successfully: 100%
3	Psychosocial Assessment	1	1	0	Mapped Successfully: 100%
3	Psychosocial Evaluation	2	2	0	Mapped Successfully: 100%
3	Selling Cars	1	1	0	Mapped Successfully: 100%
3	Social Psychology	2	2	0	Mapped Successfully: 100%
3	Song Writing	1	1	0	Mapped Successfully: 100%
3	Strategic Planning	1	1	0	Mapped Successfully: 100%
3	Team Building	1	1	0	Mapped Successfully: 100%
3	Team Development	12	12	0	Mapped Successfully: 100%
3	Not Applicable	1	0	1	One question seemed redundant
3	TOTALS	107	106	1	Total Mapped Successfully: 99%

AVERAGE PERCENTAGE OF QUESTIONS MAPPED SUCCESSFULLY = 93%

APPENDIX P. BIBLIOGRAPHY OF IN-TEXT REFERENCES

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APPENDIX Q. BIBLIOGRAPHY OF SOURCES FOR THE QUESTION-ASKING AND INSTRUCTIONAL DESIGN TABLE

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Small, R. V., & Arnone, M. P. (1988/1989). Arousing and sustaining curiosity: Lessons from the ARCS Model. *Training Research Journal, 4*, 103-116.

Small, R. V., & Arnone, M. P. (2002). *Make a PACT for Success: Designing Effective Information Presentations*: Scarecrow Press.

Spector, J. M. (2008). Expertise and Dynamic Tasks. In H. Qudrat-Ullah, J. M. Spector & P. I. Davidsen (Eds.), *Complex Decision Making* (pp. 25-37): Springer Berlin Heidelberg.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*(3), 185-233.

Utschig, T. (2005). *Key issues surrounding faculty development of expertise in instructional design*. Paper presented at the 35th ASEE/IEEE Frontiers in Education Conference, Indianapolis, Indiana.

Van Merrienboer, J., & Kirschner, P. (2012). *Ten Steps to Complex Learning: A Systematic Approach to Four-Component Instructional Design* (2nd ed.): Routledge.

Weick, K., Sutcliffe, K. M., & Obstfeld, D. (1999). Organizing for High Reliability: Processes of Collective Mindfulness. In R. S. Sutton & B. M. Staw (Eds.), *Research in Organizational Behavior* (Vol. 1, pp. 81-123). Stanford: Jai Press.

Zemke, R., & Kramlinger, T. (1982). *Figuring things out: A trainer's guide to needs and task analysis*. Cambridge, Massachusetts: Perseus Books.

APPENDIX R. VITA

SUSAN L. ROTHWELL

slrothwe@syr.edu

EDUCATION

Ph.D. Information Science and Technology. School of Information Studies, Syracuse University, Syracuse, NY

Dissertation Research Topic: To investigate the cognitive question-asking behavior of higher education faculty during conceptual instructional design and provide a basis for future research on interventions to aid designers with question-asking during design.

M.S. Information Management. Syracuse University, Syracuse, NY

M.S. Information Technology. Rochester Institute of Technology, Rochester, NY Concentrations in multimedia development and performance and learning technology.

B.S. Mechanical Engineering. Rochester Institute of Technology, Rochester, NY

A.S. Engineering Science. Monroe Community College, Rochester, NY

CERTIFICATIONS

Robert E. Ginna Nuclear Power Plant Nuclear Training Configuration Management Qualification per ANSI/ASME standards

Certified as an Intern Engineer by the State of New York

HONORS AND AWARDS

Worcester Polytechnic Institute (2013): Fellowship to attend the
7th International Conference on Axiomatic Design (ICAD) and the 2nd International Workshop on Design in Civil and Environmental Engineering (DCEE)

Syracuse University Fellow

Graduate Assistance in Areas of National Need Fellowship

ACADEMIC PROFESSIONAL EXPERIENCE

September 2010- present

Adjunct Instructor
Finger Lakes Community College, Canandaigua, NY

- CSC 100, Computing in the Information Age
- CSC 134, 135, 136,139: Core Microsoft Word, Excel, PowerPoint or Access

September 2010- December 2011

Adjunct Instructor
Bryant and Stratton College, Rochester, NY

TECH 130, Hardware and Operating Systems

Effectively redesigned the course to address the needs of a wide range of students in a new degree program. Incorporated industry and career issues with stress on effective communication and configuration management, and established a hands-on PC lab on a very limited budget.

2005- 2010

Graduate/Teaching Assistant
Syracuse University School of Information Studies, Syracuse, NY

Faculty Development: Assessment workshop, electronic archive, citation searches, revamped a publications database.

Instructional Design Support: Syllabus development, lecture revision, class observations.

IST 754, Capstone Project in Telecommunications

IST 665, Cost Modeling/Analysis of Telecommunication Systems

IST 614, Principles of Information Management for Information Professionals

ACADEMIC SERVICE

Syracuse University School of Information Studies, Syracuse, NY

Assisted with recruitment tours and activities (2004-2010).

Syracuse University School of Information Studies Assessment Committee. The first Ph.D. Student Representative. Assisted with accreditation activities. Extended to a three-year position (2005-2008).

Syracuse University School of Information Studies Undergraduate Committee, Ph.D. Student Representative (2006-2007).

Connections 2006 Doctoral Students Conference Planning Committee: Conference registration (Spring 2006).

Graduate Mentor (2005-2006). The first School of Information Studies Ph.D. Program graduate mentor.

Graduate Mentor (2004-2005). Information Management Master’s Program.

Rochester Institute of Technology, B. Thomas Golisano College of Computing and Information Sciences, Rochester, NY

Alumni Mentor, Mechanical Engineering, Rochester Institute of Technology (2009-2010).

Graduate Mentor, Course 4040-810, Research Methods. Provided assistance, resources, and mentoring in support of the first cohort of doctoral students in the new Computing and Information Sciences Ph.D. program (Fall 2007).

RESEARCH PROJECTS

Syracuse University School of Information Studies, Syracuse, NY
Center for Digital Literacy Young Innovators Project (2010-2011): Project lead for data entry, coding, and content analysis of interview data. Analyzed data from adult and young inventors to identify motivational supports and information resources used. Trained a graduate student to code and analyze data. Performed literature reviews and other supporting tasks.

Explanatory Communications Behavior Project (2006-2007): Assisted with design of a class research project for IST 641, Behavior of Information Users.

Grant proposal preparation (2006): Assisted with literature reviews, questionnaire item development, and development of a cognitive testing rubric for the *Perceived Competence in Information Skills* measure as part of early proposal development for the successful "Determination and Perceived Competence in Information Seeking in Middle School" project.

Information Seeking and Use on the Web Study (2006): Assisted with data collection interviews, data entry and coding, and content analysis.

Literature Review (2004): Assisted with literature review in conjunction with a National Science Foundation proposal for a Science of Learning Center.

Dissertation research support (2004): Coded classroom observation data for a doctoral candidate.

Rochester Institute of Technology, Rochester, NY
Independent Study Project (2005-2007): Active Learning Study, Rochester Institute of Technology. Investigated effective elements of active learning.

PROFESSIONAL EXPERIENCE

1999 – **Technical Writer/Application Help Developer**
2005 Harris RF Communications, Rochester, NY

Developed original technical manuals and context-sensitive online help for a wide range of leading-edge strategic and tactical radio frequency communications hardware and software products, including wireless communications and networking equipment and systems. Provided process improvement expertise, and assisted with software development, software and hardware testing and validation, and graphic design. Assisted with development of interactive training simulation software and online training materials for a variety of communications products. Investigated and implemented new authoring and online help development technologies.

2000- **AutoCAD Instructor**
2003 Board of Cooperative Educational Services, Fairport, NY

AutoCAD instructor in the evening Adult Education program. Responsible for classroom instruction, creation and implementation of student design projects, tutoring, assisting with student evaluation and development of teaching strategies for a 250-hour hands-on intensive course. Total of 375 hours of independent classroom teaching experience.

1990- **Training Configuration Management Coordinator**
1999 Robert E. Ginna Nuclear Power Plant, Ontario, NY

Program lead and training liaison accountable for coordination, control, development, and implementation of the Plant Configuration Change Training Program for all new/modified plant equipment, including physical systems, infrastructure, information technology hardware and software, information management systems, and process improvement at instructional, interdepartmental, and organizational levels (150 to 200 plant changes annually). Analyzed and reviewed equipment designs and technical information, communicated information on new and changing technology to training instructors and mangers, performed training needs analysis, and developed training materials for all accredited plant training programs. Regularly assisted with classroom training, coaching, and mentoring. Provided high-level input to the Institute of Nuclear Power Operations for development of industry-wide good practice guidelines for training configuration management. Rated as excellent by the Nuclear Regulatory Commission, with multiple awards for good performance.

1985- **Gas Engineering Co-op**
1988 Rochester Gas and Electric Corporation, Rochester, NY

Gas distribution network simulation and analysis.

PUBLICATIONS

Book Chapters

Small, R. V., Costa, M. R., and Rothwell, S. R. (2011). The role of information and motivation in the process of innovation. In B. Kingma (Ed.). *Academic Entrepreneurship and Community Engagement: Scholarship in Action and the Syracuse Miracle*, (Ch. 10), Cheltenham, United Kingdom: Elgar.

Rothwell, S. L. (2010). Information Technology and the Development of a Global Safety Culture: A Nuclear Perspective. In E. Blanchard, & D. Allard (Eds.), *Handbook of Research on Culturally-Aware Information Technology: Perspectives and Models* (pp. 558-581). Hershey, PA: Information Science Reference. doi:10.4018/978-1-61520-883-8.ch026

Articles in Progress

"Questioning as a Human Performance Tool: Supporting the Discipline of Design"

"Technological Interactivity Demystified: An Uncertainty-based Model"

"Internet Public Information Availability: A Longitudinal Exploration of Potential Impact on Innovation in the Commercial Nuclear Power Industry"

Other

Rothwell, S. (2007). Anti-nuclear movement. In G. Anderson, & K. Herr (Eds.), *Encyclopedia of activism and social justice.* (pp. 165-168). Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781412956215.n67

Rothwell, S. (2007). Dewey, John (1859–1952). In G. Anderson, & K. Herr (Eds.), *Encyclopedia of activism and social justice.* (pp. 452-454). Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781412956215.n253

Rothwell, S., & Yacci, M. (2007). Rand, Ayn (1905–1982). In G. Anderson, & K. Herr (Eds.), *Encyclopedia of activism and social justice.* (p. 1197). Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781412956215.n720

CONFERENCE PRESENTATIONS AND SERVICE

ICAD 2013, Worcester Polytechnic Institute, Worcester, Massachusetts. Co-chair for ICAD Session 3, Service-oriented Design on June 27, 2013.

Rothwell, Susan L. (2009, May). Creatively illustrating uncertainty: Teaching technological interactivity. Poster and technology demonstration presented at the *10th Faculty Institute on Teaching & Learning*. Rochester Institute of Technology, Rochester, NY.

Rothwell, Susan L. (2006, May). Exploring Internet information availability and the terrorist threat: A barrier to innovation for commercial nuclear power? Presented at the *Connections 2006 Doctoral Conference*. Syracuse University, Syracuse, NY.

GUEST LECTURES

Rothwell, S. (March 20, 2007). Effective PowerPoint Presentations. Invited guest speaker for IST 810/840, Ph.D. Seminar, Syracuse University School of Information Studies, Syracuse, NY.

Rothwell, S. (August 3, 2011). Design: Just a Job, or a Way of Life? Invited guest speaker for ENGRG 1060, Exploration in Engineering Seminar, at Cornell University, Ithaca, NY.

PROFESSIONAL MEMBERSHIPS

Finger Lakes Faculty Development Network, 2008 - present

The Design Society, 2008 - present

PROFESSIONAL AFFILIATIONS

American Society for Information Science and Technology (ASIS&T)

Psychology of Programming Interest Group

American Nuclear Society

The Design Society